— the sincere regards of his attache[d]
and old Pupil — The Author

JOHANN MÜLLER:

1

AN

ELOGE

PRONOUNCED

IN THE HALL OF THE UNIVERSITY OF BERLIN,

BY

PROFESSOR RUDOLPH VIRCHOW.

TRANSLATED AND EDITED

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JOHANN MÜLLER THE PHYSIOLOGIST.[1]

Nearly three months have elapsed since that spring-morning on which the startling intelligence of Johann Müller's sudden death spread through Berlin. Since then new buds have blossomed, new life has unfolded itself, and fresh activity has surrounded us on every side; but never have we forgotten the memory of that dead man, whose body we have committed to the lap of its mother-earth.

Standing by his coffin, we heard those words of comfort which, according to the custom of our country, are spoken by the priest to the relations and friends. The Academy of Sciences, at a public *séance*, has paid fit homage to the memory of its late eminent member, by the mouth of the learned man who had longest been his colleague. And pupils and friends at a distance have collected together the long list of scientific distinctions which the memorable teacher had earned by the most assiduous labour.

But no praise can bring us back the lost one; and ever more and more painful become our recollections of him whose sturdy manhood gave promise of a long duration. Daily we feel more deeply, how in him were converged innumerable ties which bound us all together; and we experience more distinctly the consciousness, that not only has his family lost its protector, but that learning has, in him, lost one of its most illustrious chiefs. Here we stand,—representatives of the great medical family, teachers and taught, practitioners and investigators,—mutually lamenting that neither cares by day, nor labours by night, can efface from our minds the sorrow which we feel for his loss. Here we are met to unite once more that bond of unity which the mere existence of this man,—towards whom we all looked,—had formed in our thoughts; and to realise with such vividness the memory of this ideal Head, whose appearance inspired us with feelings of veneration, as that it may never be effaced.

My feeble powers have been invoked to execute this great work. If the will constituted the deed, how gladly would I attempt the task!

[1] Johannes Müller. Eine Gedächtnissrede, gehalten bei der Todtenfeier am 24 July 1858 in der Aula der Universität zu Berlin, von Rudolf Virchow. Berlin: Hirschwald, 1858.

For few have been privileged, like myself, to have this great Master beside them in every stage of their development. It was his hand which guided my first steps as a medical student; his lips proclaimed my doctorate; and from that spot, whence now his cold image looks down upon us, his kindly eyes beamed warmly upon me when I delivered my first public lecture as a "*Privat-Docent*," under his Deanship. And in after years, out of the large number of his pupils, I was the only one who, by his own choice, was selected to sit beside him within the narrow circle of the Faculty.

But how can one mouth adequately praise a man who presided over the whole domain of the science of animal life; or how can one tongue depict the master-mind which extended the limits of this great kingdom, until it became too large for his own undivided government? Is it possible, in a few short minutes, to sketch the history of a conqueror, who, in restless campaigns through more than one generation, only made use of each new victory as a standpoint whereon he might set his foot, and boldly look out for fresh triumphs?

Yet such is the task to which we are called. We have to inquire what it was that raised Müller to so high a place in the estimation of his contemporaries; by what magic it was that envy became dumb before him; and by what mysterious means he contrived to enchain to himself the hearts of beginners, and so to keep them captive through many long years? Some have said,—and not without reason,—that there was something supernatural about Müller, for his whole appearance bore the stamp of the uncommon; and most certainly, from what we know of the history of his mental greatness, his commanding influence did not wholly depend on his extraordinary original endowments.

Let us see, then, what was remarkable in his development, and so perchance we may also be able to trace the influence which he exercised upon the times in which he lived.

Johann Müller was born at Coblentz, on the 14th July 1801. He first beheld the light in a stormy epoch of European history; for, only a few months previously, the Emperor and the Empire—both tottering to their downfall[1]—had ceded the left bank of the Rhine to the French Republic, by the treaty of peace signed at Luneville; and the archiepiscopal dominions of Trèves—whose electors had so long resided at Coblentz—were for ever struck out from the list of the German states. And here, where an insolent emigration had, a short time before, established its court, there presided French Préfets of the Rhine and Moselle Departments.[2]

[1] At the treaty of Luneville, 9th February 1801, the Emperor of Austria (with the concurrence of the Empire) ceded to the French Republic all the Austrian possessions on the left bank of the Rhine.—*Trans.*

[2] Goethe: *Campagne in Frankreich.* Sämmt. Werke, 1840. Bd. 25. S. 146. Thiers: *Révolution Française*, vol. i., chap. 6; vol. ii, chap. 1, 2. "C'était

By a singular chance, the French physiologist, to whom Müller has been most frequently likened,—George Cuvier,—was born at Mümpelgard, in Alsace, while that small territory still belonged to Würtemberg. Cuvier was sent to Tübingen to study theology, and only necessity compelled him to enter the *Carlschule* at Stuttgard, which has since become so celebrated. It was there that an impulse for the study of natural science was first implanted within him;[1] and from that time forward he was distingnished by a German spirit of investigation, as well as a knowledge of German literature. May we not venture to say, that the restless spirit, the readiness for quick action, the impetuous strivings after fame or gain, which since that time have so often been manifested in the politics of trans-Rhenish Germany, were also early awakened in young Müller by foreign influences, and continued to be visible throughout his life? May we not believe that, from the events which he witnessed,—the breaking up of an empire which had lasted for a thousand years, the delirium of freedom, the mighty downfall of the greatest conqueror, and the triumphant rising of a whole nation,—all compressed within a decenninm, or the brief years of boyhood,—he accumulated within himself leaven (*Gährungstoff*) enough for a lifetime, and that even thus early his opinions had outgrown the limits of authority?

We are in possession of no unmistakeable evidence as to what circumstances first stimulated the young mind of Müller. The only man of consequence who at that time paid any attention to the history of our science in Coblentz, was Joseph Görres, who, as Professor in the *Secundärschule*, or Secondary-School, published treatises on Natural Philosophy, in the departments of Organonomy and Physiology, in the years 1802–5. But it does not appear that he exercised any direct influence on Müller, who first entered the *Secundärschule* in 1810; while Görres resigned his professorship in 1814, soon after the re-conquest of the country, and was afterwards obliged to fly to France, in consequence of a work he published, called "Deutschland nnd die Revolution." But it is quite certain that his official successor, John Schultze, who for several years, in the capacity of Crown and Consistorial Councillor, snperintended the schools of the Rhenish provinces, advised Müller's father to devote his richly-gifted son to study. Among Müller's teachers there was

à Trèves, à Coblentz, qu' avaient été recueillis et organisés les émigrés; c'était de là que devaient partir les phalanges chargées d'humilier, d'abrutir, de demembrer la France. La France, au lieu d'être vainçue, était victorieuse; elle en profitait, non pour rendre le mal qu'on avait voulu lui faire, mais pour s'indemniser de la guerre qu'on lui avait faite, en exigeant sa véritable limite naturelle, la limite du Rhin."—(Vol. ix., chap. 6.)

[1] Müller himself testifies this:—"The Germans should feel proud to be able to say that Kielmeyer was the first who understood Comparative Anatomy from this, its innermost side. He who called it into life has also given to it this spiritual significance. Cuvier afterwards traced the corporeal metamorphoses of different organs throughout the whole animal kingdom."—*Zur Vergl. Physiologie des Gesichtssinnes.* Leipzig, 1826. S. 29.

only one—the mathematician, Leutzinger—to whom he himself, in his dissertation, attributed any particular share in his mental development; and we may therefore conclude, that the course which was taken by his youthful mind was not directed either by the example or influence of any specific personality. And so it becomes all the more necessary for us to consider the events of the time as the principal circumstances which determined his career. How early are dispositions and inclinations implanted in the mind of a child, which powerfully influence his after life! And how difficult is it for the education of later years, or the strength of the self-conscious will, to efface those impressions which have been strongly stamped on the pliant mind of boyhood! The example of parents, the conduct of associates, the intercourse of neighbours, the scenes of home and of town-life, the appearances of nature, and narratives of the past or present,—these are the mighty powers which early inspire us with images, with yearnings, and with thoughts which we afterwards relinquish with the utmost reluctance and difficulty. Special education determines the capabilities of any organ even more than original adaptation.

Müller's father was a shoemaker, of Moselle origin, who inhabited a small house in the Jesuits' Street in Coblentz. In spite of his limited means, he bestowed every care upon the education of his boy; and after his early death, his wife still continued to carry out his intentions towards their son.[1] But what results could she expect? A son, whose education has raised him far above the usual acquirements of the home circle, must necessarily become estranged to his family;—and he will be obliged to go abroad to find the means for satisfying most of his wishes and aspirations. Müller felt this,—that it must be himself alone who could raise the family;—that he *must* succeed! The further he advanced, the more richly would he be able to repay the love and self-denying sacrifices of his parents. His father was dead, and therefore he must become the head of the family; so a religious feeling, of a deeper intensity than mere filial affection, bound him thenceforth more closely to his mother.

Müller was educated in the faith of the Roman Catholic Church; for into the district of Trèves, which was still a spiritual kingdom, Protestantism had never yet penetrated. Catholicism had reigned paramount here for a thousand years, in all the pride of sovereignty; and, interpenetrating and encompassing all things, it early took the children under its care. It is little wonder, then, that Johann (as his oldest school-fellow relates), when about seven or eight years old, wished to become a Catholic priest. The heart of his mother must have been rejoiced by her son's idea, and no doubt his wishes received her support and commendation. So, at ten years old we

[1] In the *Curriculum Vitæ*, attached to his Inaugural Dissertation, John Müller says:—"Inde a tenera ætate parentum optimorum cura et caritate nil impedimento erat, quominus omnibus, quæ puerili animo conveniunt, imbuerer doctrinæ alimentis."

find him entering the *Secundärschule*,—an old Latin seminary of the Jesuits, of which one part remained in their possession, while another was in the occupation of the French. Here, partly under very unfavourable conditions, and partly in the scholastic forms of an obsolete mediæval education, he completed his school-boy life. To a certain extent, he made up for these defects by means of reading, in the course of which, by good fortune, he got possession of the works of Goethe. The natural beauties of his native district attracted him, and he began to collect plants and animals. Nature and Goethe! How long their impressions remained with Müller! The splendid work on fantastic expressions of the face—which he published in 1826, when an extraordinary professor—as well as his large monograph on Physiognomy, both breathe in every line Nature and Goethe.

It is not easy to part with first beliefs. That which has leavened boyhood, continues long to ferment in the breast of youth. Much after-development was needed therefore, when, in the autumn of 1819, Müller went to the University of Bonn. In the meanwhile, he had served for a year as a volunteer in the Pioneer Company of the Eighth Division; and, although he had abandoned himself to the enjoyment of the freshness and gaiety of the then less restricted life of a soldier, yet, when he now visited the University, he hesitated (as he tells us) for three whole days, whether or not he should study theology. Then, suddenly, he said to a friend,—"I have decided: I shall study medicine. Thus will I know certainly what I have, and whom I serve." To which his friend replied:—"The influence of the French Revolution has interpenetrated the minds of the educated, and has even infected the clergy; the materialism of the kingdom of nature is more attractive." So, like Cuvier, and in former times Boerhaave, Müller was lost to theology. The change which thus came over him, although very slowly, can never in its importance be over-estimated. For the shoemaker's son was, at this time, on the fair road to become a dreamy visionary. Let us hear how he himself depicts his condition:[1]—"This plasticity of fancy, both in light and dark fields of vision (*Sehfelde*), often tormented me in the years of childhood. I remember one instance very distinctly. From the window of my father's house there was visible an old-looking building, in which the lime was in some places very much blackened, while in others it had crumbled away in large fragments. At times, when I was confined to the house, and was busied at the window for several hours a day with all sorts of work, it happened that, in looking out at the fallen sooty wall of this dwelling, I could recognise numerous faces in the rents left by the fallen lime, which, by repeated observation, assumed an almost speaking expression. As the walls of this neighbouring house were for many hours the only object on which my eyes rested, and one

[1] Ueber die phantastischen Gesichtserscheinungen. Coblentz, 1826.

which always returned again in its unbroken sameness, it is little wonder that this form-creating phantasy at length endowed the monotonous landscape with a sort of life. When I tried carefully to demonstrate to others how one was compelled to see all sorts of faces in the fallen lime, I could get none to agree with me; but I saw them quite distinctly notwithstanding this. The refusals of others to recognise my fancies, only rendered me more obstinate in my belief; I cherished my revelation of the faces as something mysterious, although the phantasy existed only in my own mind. In after years—although the recollection of these figures was quite fresh in my memory—I could not discover them any longer in the crevices where they had formerly appeared." And, in another place, in the same work, Müller says:—" It is seldom that, in closing my eyes before going to sleep, I do not see numerous luminous figures in the dark field of vision. I have seen these appearances since my early youth, and I have always been perfectly able to distinguish them from the peculiar forms seen in dreams, and I have often lain thinking about them for a long time before going to sleep. By practice, I became able to call up these images, and to hold them fast after they appeared; and sleepless nights became shorter when, lying awake, I could thus commune with these peculiar creations of my eyes. Whenever I wish to behold these luminous figures, I look with completely closed and reposing eyes into the darkness of the field of vision, and with a feeling of total relaxation and perfect rest of the ocular muscles, I allow myself to sink completely into this state of psychical quiescence of the eyes, or into the darkness of the field of vision. I diligently exclude all thoughts and opinions, and—while the eyes as well as the whole organism are in a state of complete repose as far as external impressions are concerned—I only observe what may chance to appear in the darkness of my vision as a reflex of internal organic conditions in other parts."

Here we see, in Müller, the dreamer become developed into an observer, and the almost monkish visionary into a physiologist,—a happy metamorphosis, which became completed, as will be shown, in the open field of academic freedom, and in the fresh atmosphere of the interesting and eventful student-life of the period.

The German universities, at this time, were certainly in a very critical condition. When, by a national uprising, unequalled in the history of the world, Germany had driven her cruel enemies beyond her boundaries, the wretched fabric of the German Alliance was constructed from the ruins of the holy Roman Empire. The best struggles of the nation for the attainment of constitutional freedom having been repulsed, these feelings had taken shelter in the universities, while the rapidly-growing reaction, founded on the last remains of the ancient glory, was as yet undeveloped. The Wartburg festival had given a welcome handle to Russian denunciation; the dismissals of the professors had begun with Oken; E. M. Arndt and the two Welckers of Bonn were under arrest; Görres had fled;

the Carlsbad decrees had come into force; and, before the end of the year 1819, Boyen, Wilhelm von Humboldt, and Beyme had also been deposed.[1] But the students continued in opposition, and their interdicted political associations (*Burschenschaften*) survived not only in their songs, but also in the transparent mystery of their student-unions. Johann Müller was, at this time, a rollicking *Bursch;* and it is related of him that he would ride away from college, sword in hand, to the neighbouring villages, in order to preside over *Burschenschaft* meetings.

But this only lasted a short while. Like Goethe, Müller was not fond of politics; and his love of knowledge, stimulated by his rich fancy, impelled him irresistibly to the investigation of nature. Under the special guidance of Mayer, he applied himself zealously to the study of anatomy; and so enthusiastic did he soon become in this science, that he gaily exclaimed:—"Whatever is not demonstrated by the scalpel does not exist." He was instructed in the theory of physiology by the spirited and learned expositions of Friedrich Nasse, and was made familiar with it practically by the skilful Philipp von Walther. How rapidly he acquired it! When the young Rhenish University announced its first award of a prize, for a paper on respiration in the fœtus, in the year 1820, he grappled with the difficult subject, although he was then only a first-year student. Animals were procured in every possible way for his experiments; and it is amusing to hear a companion, who accompanied him on the journey, tell how he once returned to Bonn from a ride up the Ahr-valley, with a pregnant cat, which he had captured, sewed up in a sack, and fastened behind his saddle, to be robbed of its kittens by the Cæsarian section. Müller received the prize; and in 1823 published his work,[2] which was distinguished alike by the extent of its learning, and by the number and boldness of the experiments detailed. About a year before this he had published, in Oken's *Isis*, his laborious observations on the laws and ratios of motion in the different classes of animals; and in 1822, when promoted Doctor Medicinæ, he presented an Inaugural Thesis, "De Phoronomia Animalium." After this period he may be said to have stood almost entirely aloof from the public life of the nation; and the words which, thirteen years later, he spoke of the Germans, in his "Eloge of Rudolphi,"[3] may fitly be applied to himself:—"Our circumscribed geographical position has had the effect of specially directing our minds to what is hidden in the things immediately around us, and has made us so much the more expert in the

[1] HAGEN. Geschichte der neuesten Zeit vom Sturze Napoleons bis auf unsere Tage. *Braunschweig*, 1848, Band i., p. 146.

[2] De respiratione fœtus, commentatis physiologica, in academia borrusica rhenana premio ornata, c. tab. Leipzig, 1823.

[3] Gedächtnissrede auf CARL ASMUND RUDOLPHI in der öffentliche Sitzung der Academie der Wissenschaften zu Berlin, am 6 Aug. 1835, gehalten von J. Müller. Berlin, 1837.

investigation of a world of unknown inhabitants among the creatures of our native country, and in the examination alike of the structure of natural bodies, and of their internal vital processes."

The young doctor, now in his twenty-first year, was fairly in the midst of the scientific excitement. He had certainly had the ablest masters;—in Philosophy, Calker and Brandis; in Belles-Lettres, Schlegel and Delbrück; in Natural Sciences, Kastner, Nöggerath, Goldfuss, and the President of the Imperial Leopold and Charles' Academy,[1] afterwards so much tried, Nees van Esenbeck; and in Medicine, besides Mayer, Nasse, and Walther, he had been instructed by Weber, Harless, Bischoff, and Stein. But neither his cotemporaries nor his successors can tell to which of all these teachers belongs the merit of having guided and encouraged his efforts in the right direction.[2] And he resembled none of them in tendency, aspiration, or action. But, we are wrong, if we describe his development as having been wholly unassisted and self-achieved. He was a child of his time, and it is because he was so, and because—from the adverse conditions in which he was placed—he pressed irresistibly forward, that his influence became so great and so persuasive. His graduation as Doctor constituted a sharply defined boundary, from which period the earnest active life of his manhood may be said to have commenced, and from which he became a man who attracted world-wide admiration. Here then, at this point, let us pause for a little, that we may briefly glance at the history of an epoch to which we owe so much, and of which the recollection is gradually becoming more indistinct in our memories.

Throughout the whole of the Middle Ages, Aristotle and Galen had been the infallible sources of all medical and natural-historical knowledge. But when, at the time of the Reformation, the authority of Galen was overthrown by the bold investigations of Vesalius, and by the powerful, but often mystical criticisms of Paracelsus and Van Helmont, Aristotle also fell into the background. Anatomy be-

[1] This, which is one of the oldest academies in Germany, was founded in 1652 by Dr Bausch, a Franconian physician. It derives its name from the Emperors Leopold I. and Charles VI., both of whom granted it valuable privileges. It belongs to no particular district, but chooses its presidents from any part of Austria, Prussia, or the German States. The president for the time being is the keeper of the Society's archives, and also of its library, which is large and extensive. Originally it was a purely medical society, but owing to the influence of Nees van Esenbeck, it became chiefly an institution for the cultivation of natural science. It has numbered many of the most distinguished men of Germany among its members.—*Translator.*

[2] Later accounts show that Nees van Esenbeck founded a society among the students for the cultivation of natural history, of which Müller was the secretary, and also one of the most zealous members. Nees had transplanted from his native Franconia to Bonn, the profitable tendency of the Würzburg school, which, with a safe eclecticism, combined the natural history propensities of the epoch with genuine scientific empiricism. From the account given by Baer, in the introduction to one of his great embryological works, we see how permanent was the stimulus thus imparted.

came the sure groundwork of biological perceptions; and the slowly ripening sciences of chemistry and physics, furnished the means for a mechanical explanation of vital processes. The standard of philosophy was raised higher and higher by Bacon, Descartes, Spinoza, and Leibnitz; and the more extensive that the kingdom of man's knowledge grew, the bolder became the flights of the human intellect. Finally, all the accumulated treasures of knowledge, in natural history and medicine, became centred in one man,—Hermann Boerhaave,—who has justly been styled the most common instructor of all Europe. It was among his pupils that dissensions began. Albert von Haller had already made such a vast collection of the empirical discoveries of physiology, that his *Elementa* deserve to be regarded as one of the greatest works of any age. Life, in its peculiarity,—as opposed to the rest of the cycle of phenomena,—and the vital processes in their individuality, became the objects of his most zealous thought and investigation. The irritability-theory of Haller soon produced the stimulation-doctrine promulgated by Cullen, and fully developed by Brown. Numerous disciples arose; the mechanical doctrines continued to be successfully combated by the partisans of vitalism; the discovery of galvanism perplexed the intellect; and philosophy, rendered all-powerful by the glorious labours of Kant, completed the ruin of natural science. From out the darkness of this barren age there shone forth, like a meteor, the experimental researches of a man, who even to this day has always been, throughout fully sixty years, the unvarying herald of unprejudiced thought. To him will in future be applied the beautiful words which his unfortunate predecessor Forster spoke of Franklin:—"With incorruptible fidelity he continued to the last to preach freedom, justice, peace, brotherly affection, charity, and mutual forbearance, while he himself set a most noble example in the practice of all these virtues."[1] But even Alexander von Humboldt could not avert the destruction; to his astonishment, speculation floundered still deeper in the meshes of philosophy; and, it became the fashion to develope physiology out of mere abstractions. And, in the presence of such a science, the dreary mysticism of animal magnetism strutted abroad of its own accord, pretending to be an advancement made in the empirical knowledge of the world!

The natural philosophy of Schelling had taught men to deduce all phenomena from the idea of the absolute. Great investigators, like Oken, Döllinger, and Walther, gave in their adherence to this error; but, although they have the indisputable merit of having recognised, by careful observations, a series of the most important facts; and although, in particular, under Döllinger's direction, there arose at Würzburg that celebrated school of embryologists, among whom Pander, d'Alton, von Baer, and Agassiz, were the most dis-

[1] Georg. Forster, *der Naturforscher des Volkes, von Jacob. Moleschott.* Frankfurt-am-Maine. 1857. S. 70.

tinguished; still, all this was not sufficient to produce a practical return to true science; for it was easier and more convenient to explain the system without the trouble of making researches. Is it not painful for us to be obliged to relate, that it was a poet who gave the beautiful example of self-mastery (*Enthaltsamkeit*) in so frivolous an age; should we not be ashamed to confess that Goethe was obliged to rescue, for natural science, the true principles of observation? It was a strange time, in which general revolution, and anarchy in its worst form, constituted the rule. Treviranus, Blumenbach, Sömmering, and Meckel stood at almost forsaken posts.

Such was the epoch in which Müller became a doctor of medicine. Like Oken and Döllinger, he had diligently consulted nature; and he had early learned to know and to imitate Humboldt and Goethe. But he was arrested by the antitheses of natural philosophy, which seemed so ingenious; and he believed that he had discovered something of great importance, when, resting on the experiments of Ritter, he demonstrated expansion and bending of the muscles as the pole of the organic column, from which all of these, each in a straight line, diverged in the form of a circle. His descriptions revelled in all manner of half intelligible comparisons, whose distinctness was not increased by the Latin tongue; and one could perceive an old mystic fantastic impulse struggling to break out.[1] How very easily might the whole of his great development have been injured at this point! But salvation was nigh at hand. Müller was obliged to go to Berlin to pass the state-examination for a physician's license, and was absent from the atmosphere of Bonn for almost a year and a-half; when he returned again to Bonn he was quite altered: so important to a young man is the experience he learns abroad. While in Berlin he had the good fortune to come into close contact with Rudolphi, who was then engaged with the publication of his Elements of Physiology; and whose tendencies in this science, as Müller himself says, were overpoweringly anatomical and sceptical.[2] Let us hear what Muller says of this new connection:[3]—"We may often observe, in the most learned men, a retiring backwardness, which prevents them from communicating their methods to others, but which leads to the cultivation of talents which amply compensate for this. Rudolphi had great merit in this respect, for both his doctrines and his zeal were transferred to his pupils. He was easily accessible to young men; and, although

[1] Proinde flexio-extensio poli finisque vitæ motoriæ, alter tanquam calycis conclusi, alter floris explicati languentis. Ad utrumque nox, vitæ puerpera. Sed medium tenens vita multiformis ascendens descendensque viget. Ab altero ad alterum termino trames continuo polorum mutuo motu, perpetua flexionum et extensionum commutatione undulat, atque armari columna nostra animalis neque iterum iterumque cessat exarmari. Hæc respiratio monstrat, in elementa inspirationis et expirationis divisa, hæc motus animalium progressivus magis quam aliud quodcunque testatur."—*Dissertatio inauguralis de phoronomia Animalium quam scripsit et defendit. J. Müller.* Dec. 1822. Bonnæ.

[2] Gedächtnissrede auf Rudolphi, Seite 17.

[3] Ibid., p. 9.

letters of recommendation procured from him no special assistance, any one who commended himself to him by his good qualities, could always get ready access to all that he possessed, without any introduction whatever. Students, resident and foreign physicians, and naturalists, were quite at home in his library; and, as the youths were fired by his counsels, and attracted by his instructions, as well as by his library, the anatomical museum, and the private collection (which—aided by the liberality of a Banks—he had himself formed), he never lacked zealous students, who cultivated anatomy under his special guidance. His enthusiasm for science, his love of truth, his noble and disinterested character, and his powerful opposition of all false tendencies, endowed him with irresistible attractions. Such qualities as these in a teacher, give to the youthful minds of his pupils an imperishable and life-long impulse. I cannot forget the impression which Rudolphi made on myself; *for, to some extent, he founded and determined my liking for anatomy.* I enjoyed the benefits of his instruction, advice, and fatherly friendship, for a year and a-half; and, when I left Berlin, he presented me with many scientific appliances. In after years, he continued to take much interest in me, when our views were often widely different; but, he did not like to see me engaged in the province of mental physiology, and would rather have beheld me busied with investigations into the anatomy of the organs of sense—such as the eyes of insects and spiders." The following passage is also very characteristic:[1]—"Rudolphi opposed the long dominant system of natural philosophy. At every opportunity he expressed himself most forcibly against the study of nature being connected with an unintelligible philosophy, which had long spoken arrogantly for want of an exact system, and on account of the strong existing tendency towards generalisation. What Rudolphi says on this subject for the warning of the young, in his biography of Pallas, is peculiarly touching, and cannot fail to have a good effect." At least it did not fail in taking effect on Müller, who henceforward betook himself zealously to the province of careful anatomical investigation. The first fruits of this appeared in a comparatively unknown work on the Minute Anatomy and the Development of Insects, which appeared in 1825.[2] In the introduction to this book, he particularly speaks of Rudolphi's kindly offices having made his residence in Berlin both pleasant and profitable; and acknowledges that, in many respects, he felt himself under perpetual obligations to his teacher. The copy of this work, which I have examined, chanced accidentally to contain a very interesting

[1] Ibid., Seite 14.

[2] On the development of the ova in the ovary of the Ichneumon-grasshopper, and a newly discovered connection of the dorsal vessels with the ovaries in insects. (Joh. Müller, über die Entwicklung der Eier im Eierstock bei den Gespenstheuschrecken und eine neuentdeckte Verbindung des Rückengefässes mit den Eierstöcken bei den Insecten. Mit 6 Kupfertaf. *Nov. Act. Acad. Car. Leop. Nat. Cur.* Vol. xii., p. 2.

note in Müller's handwriting. "To Professor Hegel, these pages are offered in token of the gratitude felt by his deeply-indebted pupil, Dr Johann Müller." We learn from this, that Müller had also prosecuted philosophical studies during his residenee at Berlin —a comparatively unknown circumstance, whieh is confirmed by private accounts, and one which was quite to be expected in so ardent an admirer of Aristotle, Bacon, and Giordano Bruno.[1] But Müller's connection with natural philosophy was at an end; the great turning-point had been passed; and we may safely asert, that it was our University (Berlin) which won him over to strict seience.

He now returned to Bonn; and, on the 19th Oetober 1824, established himself as a private lecturer, or *Privat-Docent*. Here he laid down his new confession of faith in his publie leetures; and exposed the "poverty of a physiology founded on a philosophical view of nature." He showed that neither the mythic nor the mystic treatment of physiology; that neither the "false natural philosophy," nor the rationalistic,—or, as he said, the "intelleetual"—physiology, constituted true science; and he maintained that, in the existence of an intimate union between a progressive physiology,— founded on observation and experiment,—and philosophy, lay our only security against all such one-sided systems.[2] As he has beautifully said:[3] "Natural philosophy has a kind of religion of its own; it has also its worship,—I believe we may add, it has a perpetual priesthood. There is an experience which is only developed from ideas; and, out of such experienees again ideas directly arise, because the former act like the institutes of a religious worship. This simple and unpretending contemplation of nature, which is constrained in itself to recognise only the rights of all things, and the truth of their appearances, is the mind of the natural philosopher, and particularly of the physiologist. Let such a spirit examine whatever you choose, it always pereeives more than is distinctly visible to the senses in the thing itself; and, as its experienees and views proeeed from ideas, so to ideas they return. I recollect how, in the 'Views of Nature,' also by Alexander von Humboldt, and in Goethe's treatises on natural philosophy, experience aeted as the propagative ferment of the intelleet. Abstract meditation about nature is not the province of the physiologist, who examines nature in order that he may think about it."

Now commenced a most restless and exhausting period of Müller's life, in which he not only lectured on general and comparative anatomy, but also on general pathology, and pathological anatomy, as well as on diseases of the eye and ear. His earliest scholars have

[1] Throughout life, Müller continued true to Aristotle. In his lectures he inspired his students with an admiration of this old natural philosopher; and it is to his stimulus that we owe the new translation of the four books of Aristotle on the parts of animals, which was published at Leipzig in 1853, by A. von Frantzius.

[2] Zur Vergleich-Physiologie des Gesichtssinnes, Seite 18. [3] Ibid. S. 34.

described his delivery as rugged and difficult; and, in fact, if we examine all his works from his first speech to his great Physiology, we will everywhere see evidences of an industry, which was specially restrained by the multitude of facts, the carefulness of quotations, and the pressure of thought; and which, though fettered by warmth of sensibility, earnestness of effort, and truthfulness of perception, continued to toil on willingly to the end! No rest! no repose!

His little work on "Fantastic Appearances of the Face," appeared like a pleasant idyll in this time of impetuous labour; and behind, in classic repose, the "physiological documents of Aristotle" brooded over the dream. The work is everywhere excellently arranged; the materials are well prepared and concisely expressed; observations and experiments are in perfect unity; and the mind is often directed to a retrospective glance at the history of the world. This book he offered as a bridal gift to his betrothed.

But his exertions had been too great. The poor *Privat-Docent* had widened the circle of his researches with much difficulty and anxious care; and he had sacrificed his hardly-earned means to the cause of science. The time which it had taken him to achieve this was not sufficient to enable a man of inferior ability to do a fraction of the work. He had taught, read, investigated, experimented, and at first had even practised as a physician![1] And then, after the fatigues of the day, he was in the habit of taking coffee as a stimulus, to enable him to prosecute his still more arduous and difficult researches on subjective vision. He had scarcely been created Extraordinary Professor in 1826, and had hardly brought home his bride in 1827, when his strength broke down. He felt himself exhausted; his nights were sleepless, and his mind was uneasy and despondent. Philipp von Walther, his kind teacher, aided by his old friend, John Schultze, obtained leave of absence and assistance for him from the Government. So, he first went up the Rhine, accompanied by his young wife, in order to visit Tiedemann, at Heidelberg; then he wandered through Southern Germany; and, finally, he returned to his usual active life, reinvigorated in health and enriched by many new views. But he was no longer the Müller of former days. The great internal catastrophe had changed his mistrust in phantasy to positive dislike. In full consciousness of his own powers, he had now a want of confidence in himself; and, in every sense, he had become cold and calculating. At this point of his career, great success and celebrity may be said to have been inaugurated by the ordinary Professorship in the University of Bonn which was bestowed upon him.

Never did the path of investigation behold him so certain of success, so brave in courage, or so lofty in aim as at this time. He achieved greater things at a later period, but he never purposed

[1] Müller says, that he renounced medical practice on account of the unfortunate circumstance of his first patient—a young friend—having died from peritonitis, occasioned by perforation of the bowel.

doing so much. His two books on "Comparative Physiology," and on the "Fantastic Appearances of the Face," are most interesting documents to those who devote attention to the development of the human mind. Here, for the first time, we see a true flesh-and-blood natural philosopher, exploring all the paths of knowledge, and seizing every method of observation, that the great problems of the most important senses of sight and hearing might be rendered accessible to science. Animals of all kinds were assembled, that he might become fully acquainted with the structure of the eye; mathematics and physics were made serviceable to establish the laws which govern light and sound; poets and sculptors of every age were brought, by the hand of the philological interpreter, before the judgment-seat of physiology, to render account of the wondrous diversities of the human countenance; and ecclesiastical and secular historians were summoned before philosophy, in order that mankind might for ever be delivered from the visions of the mystics, from witches, and from devils. And soon—in extensive views of nature, in the hidden recesses of literature, and in the privacy of his own ocular observation,—the ardent inquirer grasped the veil which concealed the inner workings (*Vorgänge*) of the special senses from his conscious intelligence. He openly declared that he sought to find the way to the soul through the senses.[1] "The present inquiry," says he, "treats of the sense of sight in its higher social relations to the organs, whose form of life we call psychical or spiritual. The author believes the soul to be only one special variety of the manifold forms of life, which are the subjects of physiological research; and hence, he entertains the conviction, that physiological investigation must eventually be psychological in its ultimate results. The doctrine of the life of the soul, as a special form of life of the organism, is therefore only a province of physiology in the wider sense of the word; which province—in opposition to physiology, and a narrower meaning of the science—is called psychology. For what we generally term psychology, occupies the same relation to the future doctrine of the life of the soul, as the ordinary physiology of the various functions does to true physiological science." And he makes the further important remarks: "Were the author, in short, called upon to declare what he considered to be a scientific physiological treatise on psychology—while carefully guarding himself against the suspicion of Spinozism—he would unhesitatingly name the three last books of Spinoza, which treat of the Passions; and the psychological contents of which may be regarded as quite independent of the other doctrines of this writer. If these be not the correct doctrines concerning life in the passions; and, if they be not the true explanation of life in this form, there can at least be no doubt whatever that they constitute a concise and methodical exposition of life, which cannot be said of most

[1] Phantastische Gesichtserscheinungen. Vorwort, S. iii.

physiological researches." Here we see Müller trying to give vitality to the idea which he had already promulgated in two Theses of his Inaugural Dissertation, that only the physiologist could be a psychologist, and that independent of nature there was no philosophy. In fact, he had constructed mental philosophy wholly from nature; and in him the doctrines of Goethe,[1] Steinbuch, and the venerable, thoughtful Purkinje, had found corroboration and fulfilment.

But all that was now past. Müller, who had so energetically defended observation in opposition to experiment,[2] now returned to experiment, which he had so regardlessly practised as a young student. Having had an opportunity—while with Rudolphi in Berlin[3]—of witnessing experiments on the functions of the trigeminus and facialis nerves, in corroboration of Bell's dogmas, he finally succeeded in showing an easy mode of performing experiments on the anterior and posterior roots of the spinal nerves.[5] As is also well known, it was he who introduced to the knowledge of physiologists and physicians the doctrine of reflex-actions, which had been already indicated by Prochaska, and which was simultaneously discovered by Marshall Hall and himself. Thus he had the high privilege of establishing, for all time, two of the greatest practical discoveries of the physiology of the nervous system. Next to the nerves, the blood became the subject of his researches; and, he not only naturalised in German medicine the accurate knowledge of the fibrin and blood corpuscles, which Hewson had cultivated with such fertility in English literature, but he also managed, by simple experiments, to demonstrate the peculiar composition of the vital fluid.[5] The discernment of right methods of investigation lay ever open to his clear and cultivated intellect; and he knew full well that there were cases in which the scalpel and experiments could not determine a question, and where the truth was only to be elicited by means of chemical reagents and physical instruments.

[1] "In the year 1828, I had an opportunity of conversing with Goethe upon this subject, in which we were both much interested. He knew that I frequently saw different figures in the field of vision, when I lay quietly down to sleep, with my eyes closed, but before sleep had actually come on; and he was very desirous of learning what forms these images took in my case. I explained to him, that I had no voluntary power over either the production of these images or their changes of form, and that they never presented the slightest tendency to a symmetrical and vegetative development. Goethe, on the contrary, was able to give the type for the phantasm, and then the different variations ensued in it, as it seemed, independently of the will, though with regularity and symmetry. This difference accorded well with the characters of our minds, of which the one had all the creative power of the poet, while the other was engaged in the investigation of the actual phenomena of nature." *Müller's Physiology*—Dr Baly's Translation, vol. ii., p. 1395.

[2] Zur vergleich. Physiologie des Gesichtssinnes, S. 20.

[3] Gedächtnissrede auf Rudolphi, S. 18.

[4] His method of experimenting on frogs. See his *Physiology*, Dr Baly's translation, vol. i., p. 642. (*Translator.*)

[5] E. F. Burdach's Physiologie als Erfahrungs-Wissenschaft. 1832. Band. iv.

It was thus he discovered the peculiar gelatinous substance found in cartilage, called Chondrin;[1] it was thus he proved the existence of lymphatic hearts in the *Amphibiæ*;[2] and it was thus that he determined not only the organs,[3] but all the laws which are concerned in the production of the human voice.

But in thus grouping together some of the more important of Müller's labours, which belonged to a period distinguished for great things, we have somewhat anticipated our historical narrative. The special researches of the Bonn epoch are those on the minute structure and anatomy of the glands,[4] which ended the controversy that had existed so long between the adherents of Malpighi and Ruysch, concerning the sacculated extremities of the glandular follicles, and obtained for us a correct knowledge of these important organs throughout the whole animal kingdom. Likewise, those on the development of the genitals,[5] which have inseparably connected Müller's name with the structures surrounding the Fallopian tube ("Müller's Filaments"), and which are so decisive in explanation of hermaphroditism. To these were added, somewhat later, his important works on the organic nerves of the erectile organs;[6] on the structure of these organs in the ostrich;[7] and on the *arteriæ helicinæ*.[8] In 1833 he began to collect the abundance of his knowledge in the great *Handbuch der Physiologie des Menschen*, or Manual of Human Physiology, which went through four editions, and in the form of several translations, became the basis of all instruction. It was a book in which was concentrated the whole fulness of our knowledge of the forms and processes of animal and human life for the first, and perhaps, the last time, since the days of Haller; and which constituted its author the first living authority in physiology. His star had already risen by the side of that of Cuvier, who was styled by French writers the honour of their country, and of our century. Seldom has a savan deserved his reputation more than Müller, and seldom has any one been more

[1] Poggendorf's Annalen. Bd. 38, S. 295.

[2] Ibid. 1832, Aug. Also Philos. Transact., 1833, and Abhand, der Berlin Academie, 1839.

[3] Ueber die Compensation der Kräfte am menschlichen Stimmorgan. Berlin, 1839. Ueber die bisher unbekannten typischen Verschiedenheiten der Stimmorgane der Passerinen: Abhand. d. Berlin Acad. 1845-46. See also *Physiology*. Baly's Trans., vol. ii., p. 1002.

[4] De Glandularum secernentium structura penitiori earumque prima formatione in homine atque animalibus. Leipzig, 1830.

[5] Bildungsgeschichte der Genitalien aus anatomischen Untersuchungen an Embryon des Menschen und der Thiere, nebst einem Anhango über die Chirurgische Behandlung der Hypospadie. Düsseldorf, 1830.

[6] Ueber die organischen Nerven der erectilen männlichen Geschlechtsorgane des Menschen und der Säugethiere. Berlin, 1836.

[7] Ueber zwei verschiedene Typen in dem Bau der erectilen männlichen Geschlechstorgane bei den straussenartigen Vögeln und über die Entwickelungsformen dieser Organe unter den Wirbelthieren ueberhaupt. Berlin, 1838.

[8] Müller's Archiv. 1835.

lucky in his acquisition of fame. Cuvier died—a Peer of France—in the spring of 1832; and Rudolphi also died in the autumn of the same year. Which of the German anatomists and physiologists was more entitled than Müller to aspire to the Chair thus rendered vacant in the Berlin Faculty? Presently all was in full activity; candidates sprung up on every side; and those who were the least qualified, considered themselves best fitted for deciding the election. Even a Minister, the late Baron Stein von Altenstein, could not resist these influences, and negociations were opened with Tiedemann. Müller then determined on taking an unusual step, which, however, illustrates well his firm decision of character; he declared that he would yield his claims to none but John Fr. Meckel; and that, with this exception, he considered himself as the first physiologist in Germany. By the agency of John Schultze, a letter from Müller was laid before the Minister, in which he specified his qualifications for the office; and this letter—which unfortunately appears to have been lost—is described as having been one of his most remarkable and beautiful compositions; and so powerful was the impression which it made on the Minister, that he immediately appointed the writer to the vacant Chair.

And, in fact, who was better fitted than he for holding the first anatomical position in Germany? To afford Müller more leisure, he was not only allowed a prosector, but a sub-professor of anatomy. Schlemm was also appointed to assist him; for it was considered that simple anatomical instruction—although of the highest importance—did not require to be given by so eminent a teacher, but that the young and rapidly growing sciences of physiology and comparative anatomy demanded, at the first University of Germany, the undivided energies of a professor.[1] It was a fortunate choice: the right man was in the right place. Müller next busied himself with the completion of his "Handbook of Physiology;" and with it his own development as a physiologist in the stricter sense of the word was also concluded. It has been said that, in this

[1] Surely, in this arrangement, there was sound practical wisdom, from which we may take a useful hint in the present discussion of the Scottish University question. The rough drudgery of all kinds of preliminary instruction should be done by assistants; and so, the Professors would have more time at their disposal, not only for the cultivation and advancement of learning, but also for rendering their pupils more highly educated men. What can we expect from the present system of University education which compels some of the finest scholars in the kingdom,—such men as Lushington, Blackie, Ramsay, Pillans, Kelland and others,—to teach raw country lads the elementary knowledge which they should have acquired in the schools, or from tutors? "Why," asks the *Illustrated London News*, October 9, in an admirable article on the subject, "should a steam-engine of a hundred horse power be employed to draw up a few buckets of water from a well, while the paper-mill or mining-work for which that steam-engine was constructed, is left unperformed?" If our Professors must spend their sessions in such employment, it is truly little wonder if the standard of scholarship in Scotland be so miserably low.—(*Translator.*)

work he specially established an experimental physiology. But this is not correct; Müller was no more an experimentalist than Haller; and he himself heartily detested the tendency which experimental physiology had assumed in France through the agency of Legallois and Magendie. This repugnance was based on the strong objections which he had alike against the methods of the experimentalists and the credibility of the experiments themselves; yet it can hardly be doubted that a great deal of this aversion was purely æsthetic. He says of Rudolphi:[1] "He looked upon physiological experiences as having no relation to anatomical accuracy, so it is no wonder that this admirable man, who at every opportunity expressed his abhorrence of vivisection, took up a hostile position against all hypotheses and ill-established physiological experiences. We could not have failed to share his righteous indignation, had we seen how many physiologists were using every effort to reduce physiology to an experimental science, by the live-dissections and agonies of innumerable animals, undertaken without any definite plan, and yielding often only insignificant and imperfect results." Müller openly shared these views of Rudolphi; indeed, it is questionable if they were not his own; at least, it is certain that he continued to devote himself more and more to observation, and especially to anatomy. So he at last became once more estranged from physiology, and there seems little doubt that he, who had always been considered so peculiarly a physiologist, latterly contemplated the discontinuance of his teaching that science.

There are two qualities in his *Hand-Book of Physiology*, which have particularly enhanced my estimation of its value—its strictly philosophical method, and its completeness in facts.[2] Since the time

[1] Gedüchtnissrede. P. 18.

[2] Müller himself speaks very plainly about his aims, in the preface to his *Bildungsgeschichte der Genitalien*:—"I have certainly always been friendly to a methodically arranged, thoughtful, well-digested, or (what is the same thing) a philosophical treatment of a subject. For I look upon philosophical comprehension and rational perception as equally important. I do not thereby allude to that kind of knowledge which arrives at results without an adequate empirical basis, nor to the so-called method of the natural philosophers, which I have already attempted to characterise, when I described it as a false system of natural science, which yields to the seductions of past ages, and would fain carry us back to the times of an obsolete philosophy." "What I term a philosophic method has nothing in common with the dogmatic. I demand, first of all, *unweariedness in observation and experience:* this is the principal duty which I impose on myself, and continually strive to fulfil."

"I hold that our experiences, when they are sufficiently extensive and accurate, should not merely be gathered together, but that—as nature proceeds in the development and preservation of organic beings—we should endeavour to form the various parts from the whole, if, by analytical means, we have recognised the individualities, and succeeded in comprehending the whole." He then refers to Caspar Fried. Wolff, Goethe, Sniadetzki, and Treviranus; he demands "good" experiments, which, he has proved, can separate the real from the accidental, and shows the need of "true observation." Finally, he says:—"I need scarcely remark, that it is the duty of a scholar to make himself

of Haller no one had so thoroughly mastered the entire literature of Natural History, or collected, in all directions, so many original experiences; and no one had been, at the same time, familiar with medical practice, as well as with the remotest provinces of zoology. It has been well said, that while Haller often, in doubtful questions, espoused a side which must eventually be forced to succumb, Müller always had the luck (if we may call that "luck" which was preceded by so much intelligent activity) sooner or later to discern the party who were sure of the victory. He was wonderfully fitted for being a critic, by his comprehensive knowledge. He knew how to discriminate the healthy from the unsound, the essential or real from the adventitious or accidental. And, in surveying the whole series of forms—often widely different—among which a well-determined plan of nature[1] seemed to be realised, he knew the changes which, not unfrequently, altered considerably the arrangement and composition of the substances within these forms. In Müller, as a physiologist, it is not the genius of the discoverer,[2] nor the path-preparing (*bahn-*

acquainted with the progress of science among all nations; and this is now possible, and, moreover, quite indispensable in these days of progress. *A purely German, French, or English School of Medical Science is barbarism;* and in Germany, we would consider the idea of an isolated English or French system of Natural History, Physiology, or Medicine, just as barbarous as the notion of Prussian, Bavarian, or Austrian Medicine or Physiology."

In the Annual Report for 1833 (*M.'s Archiv.* 1834) he says:—" This tendency, which some call the philosophical method, was inevitable, after such great discoveries in the history of development. For, just as these have shown us the natural formation of organs, out of material possessed of productive powers, and also the invariable development of separate parts from a Whole—in which these parts did not pre-exist ready formed, but which only possessed the power of their evolution—so do we likewise find, that the theory of anatomy must not at first consist of fruitless speculations. Meritorious men, who deny that philosophy is able to fathom the secrets of nature, must at length silently perceive how Nature herself, in the history of development, reveals the plan of her thoughtful operations, and feel that the progress of observation, in such cases, is part of the work of the meditative mind."

[1] John Fr. Meckel had explained very circumstantially and ingeniously the laws of diversity and reduction. Meanwhile there remained, according to the opinions of the natural philosophers, a possibility of tracing back the diversities of form to certain invariable fundamental types, whence it followed that each of the higher animals must have successively passed through the developmental forms of those lower in the scale of existence. This bold cosmogonistic thought had already been opposed by Müller in the Theses of his Inaugural Dissertation, *Non datur Scala Animalium*, and he thus referred to it in his remarks on Rudolphi:—" He opposed the idea, that man passes through the other lower types of animals in the course of his development, and therein he was correct."

[2] Müller says, in the Annual Report for 1833 (*loc. cit.*):—" Great discoveries have hitherto been extraordinarily rare in the history of physiological science; and, if we reckon those which have brought about a total reform in our previous notions of physiology and pathology, we will find that two only can be regarded as of primary importance, viz., the discovery of the circulation, and of the different functions of the anterior and posterior roots of the spinal nerves, which is the greatest honour of modern times. To these may be added,

brechenden) flights of the observer, but rather the methodical exactness of investigation, the calculating judgment, the confident tranquillity, and the perfect consummation of his knowledge.

Thus did the reform of newer views become embodied in him; and, in spite of the almost monastic retirement of the scholar, its influence was not limited to physiology, but continued to spread beyond it in ever-widening circles. He vanquished mysticism and phantasms in the organic kingdom; and he was most distinctly opposed to every dangerous tendency, whether it was pursued under the pretext of philosophy, or belief, or merely in accordance with conjectures.[1] He did not discover, but he firmly established, the "exact" method of investigating natural science. *Hence he did not found a school, in the sense of dogmas,—for he taught none,—but only in the sense of methods.*[2] The school of natural science which Müller created knew no community of doctrine, but only of facts, and still

an important discovery in animal chemistry—the observations of Wöhler on the artificial composition of urea,—a fact which promises to prove of infinite importance to physiology."

[1] "Phenomena of a higher or lower order cannot, in subjective vision, present themselves to our notice through the influence of direct external influences, but only by means of the internal revelations of our organs. And so, throughout the whole creation, the God-like graciously reveals itself in various ways, to different people; to those who are gifted with rich, elevated fancy, it appears in the form of phantasy; to the pious, in goodness of disposition; to the wise, in wisdom; and to the strong, in the greatness of his works, for in all of these modes it is adored by some of us."—(*Phantast Gesichtserschein.* S. 63) . . . "Fancy is the organ of the mind, which gives rise to most of the errors in natural science; for it destroys in the bud our results, as well as our observations. At the same time, it is an indispensable benefit, for by means of it new combinations are created as inducements to make still more important discoveries. A capability of discriminating isolated meanings, as well as an enlarged and comprehensive fancy, should both, in the breast of the physiologist, have a harmonious interchange of action. If this balance of power between them be disturbed, fancy converts the natural philosopher into a dreamer, while the proper use of these gifts enables the talented investigator to make most important discoveries."—*Archiv.* 1834.

[2] To illustrate his method of investigation, let the following example suffice:—In 1846, when I was prosecutor at the *Charité* Hospital, I repeatedly met with a pathological condition of the spleen, which I afterwards characterised as the "sago-spleen." I had long tried to discover the meaning of this appearance, but without being able to ascertain more than that small homogeneous granules occupied the place of the Malpighian bodies. Some considered that they might be dependent on the follicles. I showed such a spleen to Müller, in hopes that, as he had devoted attention to this organ, he might be able to give me some opinion as to the follicular origin of the granules, as well as some explanation of the nature of the changes which were present. He did not know this pathological condition, and was doubtful as to whether it arose from follicles; and he said—"It is very strange,—you must investigate this." When I told him at another time that I had done so, but that I was not content with the results, he said:—"You must investigate this still further,—it is certainly very interesting." Seven years afterwards I succeeded in demonstrating the iodine-reaction of these bodies, and in classing them among the Amyloid-substances which have since been shown to be so numerous.—(*Acad. des Sciences*, Dec. 1853).

more of methods. He cannot be held responsible for the growth of any excrescences which spring from this school, and still less for its having preached a Materialism, which was almost as dogmatic as the Spiritualism and Orthodoxy against which he had warred. Like all of us, Müller regarded psychical existence as one of the forms of life, but he was far too rigid with himself, and far too judicious in the use he made of his own observations, to have permitted himself to disrespect the authority of those thinkers whose views were not directly based on natural experiences. He openly recognised the rights of Fancy and of Philosophy, and he left a free path for all positive religious beliefs. And here he knew how to preserve the balance.[1] Feeling convinced that religion was a matter of individual belief, he never alluded to the subject either in his writings or in his lectures. Yet he himself was—what he styled one of his greatest predecessors—perpetually a Priest of Nature; the religion which he served attached his pupils to him, as it were, by a sacred bond; and the earnest priest-like manner of his speech and gestures[2] completed

[1] In the Sixth Book of his Physiology, which treats of the mind, he first speaks of the mind of animals,—"Everything which feels and moves voluntarily, in accordance with its desires, is endowed with a mind, as Aristotle teaches in his Treatise on the Mind." Then he points out how the mind must be identical with the vital principle, and shows that they must both exist throughout the whole of the organism, although the operations of intelligence are confined to the brain. Hence he concludes that both the mind and the body are capable of being divided, since the vital principle must exist in a latent state in all matter. "This," says he, "is the furthest limit which our actual knowledge enables us to reach in the investigation of the relation subsisting between the vital and mental principles on the one hand, and organization and matter on the other. At this point we are constrained to leave the field of empirical physiology, and to enter that of hypothetical speculation and philosophy. In the whole of the foregoing exposition of physiological doctrine, I have carefully avoided all considerations of the latter kind, my object having been, by a careful induction from facts, to develope those views which have the greatest semblance of truth in their favour. Moreover, as it appears to me very unadvisable to adopt any other mode of inquiry in our science, or arbitrarily to exchange the strictly inductive method for that of mere speculation, I shall, in the following pages, confine myself to a simple exposition of the two alternatives—the idealistic and the pantheistic views—without supporting either the one or the other. I shall not follow exclusively any special form of philosophy, but shall explain both systems without mixing up with them the consideration of physiological facts, though, at the same time, I shall endeavour to make their bearing on those facts as evident as possible."—(See *Dr Baly's Translation*, vol. ii., p. 1337.)

[2] I must confess that Müller, in his lectures and in his manner, reminded one of a Catholic priest, which might be accounted for by the impressions of his early childhood. When, as Dean of Faculty, he mounted the *cathedrâ superior*, dressed in his official robes, and pronounced the Latin formulary of the proclamations of the Doctors of Medicine with short, broken, and contracted words; when he began his ordinary lectures in almost murmured syllables; or when, with religious earnestness, he was discussing any of the abstruse questions of physiology,—his tone and manner, his gestures and look, all betrayed the traditionary training of the Catholic priest. His early study of the human countenance had not been made in vain. "It is remarkable," says he, "how, in the passions of envy, contempt, and abhorrence, as well as in the look of

the feeling of veneration with which every one regarded him. With a trace of severity in his mouth and compressed lips; with an expression of the most earnest thought on his brow and eyes; and with the remembrance of a finished work in every wrinkle of his countenance—this great man ministered before the altar of nature,—freed, by his own power, from the trammels of his early training and tendencies—a noble example of personal independence!

While as yet his *Physiology* was not fairly before the public, he read in the Academy a series of discourses on the comparative anatomy of the *Myxinidae*,[1] a work which had never been equalled in its completeness. By selecting animals which belonged to the lowest grade of fishes, and consequently of the *Vertebrata*, as the point from which he set out in his comparisons, it was possible to exhibit the type of vertebrate animals in its simplest form, and to trace its evolution from this upwards to that of man. Thus did he satisfy the yearnings of Natural Philosophy, which had hitherto possessed only a defective knowledge of the finer structure of those animals which formed the boundaries of the great vertebrate kingdom, and which was now enabled, by the partial confirmations of comparative anatomy, to unfold the views which the study of develop-

punishment or disgrace, the motion of the eyes are rectilinear, so that the person under notice can be measured by the eyes, which are seen by the observer to contradict the prepossessing general appearance which the individual may possess. Men do not like to be fixed or measured by the eyes, but only to be noticed."—(*Zur vergleich. Physiol des Gesichtssinnes*). Yet he sometimes fixed his eye upon some unfortunate student, till he timidly disappeared from his place in the college. What a contrast it was, when the face, so dark or cold at other times, was lit up by an expression of the most cordial kindliness, and his eye laughed more than his face,—beaming like a warm sunbeam breaking from behind dark clouds! At such times Müller was fascinating, for then his spiritual greatness was most revealed. There seemed to be an adaptation of nature in the contrast between his wonderfully large head, and his bodily frame which was only characteristic for the breadth of his shoulders. His body and limbs had not the nimbleness and agility which are acquired by early habits or natural conformation, but they were rendered more elastic and obedient by gymnastic and anatomical exercises. It is well known that Müller had educated almost every one of his muscles to obey his will, and that he could make the iris, the ears, and even the small bones of the ear, move in obedience to his volition. He must have made great progress since the period of his military service, concerning which an eye-witness relates the following anecdote:—"Once, when we were at parade, and the command, 'order arms,' had been given, he amused himself inserting one finger after another into the muzzle of the firelock, until at last his middle finger got fairly wedged into it. Then, when the order of 'attention' was given, Müller could not obey it; and, when he was brought to the front before the captain and major, his comrades laughed at his ridiculous position. He was sent home, and the surgeon had no little trouble in liberating the thickly-swollen finger."

[1] Vergleichende Anatomie der Myxinoiden, der Cyclostomen mit durchbohrten Gaumen.—I. Osteologie und Myologie (Abh. der Acad. von 1834). *Berlin*, 1835.—II. Ueber den eigenthümlichen Bau des Gehörsorgans bei den Cyclostomen, mit Bemerkungen über die ungleiche Ausbildung der Sinnesorgane bei den Myxinoiden. *Berlin*, 1838.—III. Vergleichende Neurologie der Myxinoiden. *Berlin*, 1840.—IV. Gefäss-system. *Berlin*, 1841.

ment, by longer and less easy methods, had taught concerning the Chorda Dorsalis, the structure of the vertebrae, the significations of the various parts of the brain and skeleton, and the right comprehension of the muscles and intestinal canal. Here, also, a beginning was made for the foundation of a system of comparative histology.

To his researches on the *Myxinidae*, he added a vast series of investigations on fishes. He showed that the lowest known development of brain existed in the branchiosteous fishes;[1] and he brought into notice the "smooth-shark" of Aristotle, which had escaped the notice of physiologists for two thousand years,[2] and in the yolk of whose ova that peculiarity was first observed, which he afterwards illustrated in detail.[3] Then, in conjunction with Henle, he gave a description of the *Plagiostomata*;[4] and, finally, following in the path of Agassiz, he published his celebrated work on the *Ganoidea*,[5] and on the natural system of fishes, which has been so important to subsequent inquirers.

Meanwhile, as a continuation of the journal edited by Reil and Meckel, he had established the *Archives*, which bore his name, and continued to be so celebrated until his death; and had commenced to furnish an annual report on all the various branches of anatomical and physiological science. These, and the valuable collection obtained for the University from Walther, gave a stimulus to his zeal for pathological anatomy, which had for a long time been somewhat diminished. In his Annual Reports for 1834 and 1836, he speaks out plainly, and vigorously attacks those physicians who do nothing themselves for the advancement of physiology, and yet expect everything from it. "May the genius soon appear," he exclaims, "who, himself an investigator in the chemical, pathological, and microscopical analysis of morbid forms, will establish a system of general pathology worthy of the medical and natural sciences, securely based upon a more earnest foundation of philosophical examples, of natural science, history, medicine, and physiology. From the pure physiologist we cannot expect this achievement; it is a problem for physicians, and one worthy of the highest talents. A certain share of the work must fall to the anatomist and physiologist, viz., the general anatomy of pathological tissues; and this demand upon them they

[1] Ueber den Bau und die Lebenserscheinungen von Branchiostoma lubricum Costa, Amphioxus lanceolatus Yarrel. *Berlin*, 1844.

[2] Ueber den glatten Hai des Aristoteles und über die Verschiedenheiten unter den Haifischen und Rochen in der Entwickelung des Eies (Abh. von 1839–40). *Berlin*, 1840.

[3] Virchow. Ueber die Dotterplättchen bei Fischen und Amphibien. Zeitschrift. f. Wiss. Zoolog. 1852. Bd. IV.

[4] Müller und Henle. Systematische Beschreibung der Plagiostomen. Berlin, 1838–41.

[5] Ueber den Bau und die Grenzen der Ganoiden und über das natürliche Systeme der Fische (Acad. Abhand 1844. Berlin, 1846.

are certain to fulfil, according to the present spirit of our science."[1] And Müller lost no time in beginning to assist in this work. In an oration which he delivered, as Professor of the Military Academy,[2] on the 2d August 1836, he communicated a series of important discoveries which he had made on the minuter structure of tumours,—as, for instance, of enchondroma; and two years afterwards appeared the first part of a large work on the finer histology of tumours, which unfortunately was never completed.[3]

It was just at this time that the employment of the microscope as a means of investigation had begun to assume such unexpected importance, through the influence of Treviranus, Ehrenberg, Purkinje, and others. Müller had for a long while worked with the microscope,—at first with an instrument presented to him by Rudolphi,[4] —but he had several times expressed his opinion, that it was only of particular utility in the examination of isolated particles, or of thoroughly transparent textures; and even now he could not be convinced that there existed any necessity for physicians to acquire the ability of making microscopical examinations for themselves.[5] Purkinje's discoveries of the structure of the bones induced Müller to repeat his observations, and to study minutely the deposition of the lime in the bones; and, by his advice, Miescher began to investigate inflammation of these structures. Robert Froriep, and his pupils, Gluge, G. Simon, and others, had entered the new path zealously, and had begun to render it accessible to medical practice. The great success of Schleiden's cellular-theory of plants stimulated Schwann—Müller's assistant in the Museum—to make those comprehensive and magnificent investigations on the cell-structure of the animal tissues, on which our last advances in pathological science so essentially depend. It was Müller who followed up these discoveries, and, in particular, who first demonstrated the harmony which existed between the pathological and the embryonic development of tumours,—a physiological observation of the highest importance, which, as we now know, is the key to the whole doctrine of morbid new formations. Only the blastema-theory, with which it was united, prevented it from soon being fully successful; and the doctrine of the specific nature of the elements of tumours, which arose soon afterwards,—in direct opposition to Müller's views,—caused a divergence into tedious by-paths. Of this much, however, we are certain, that Müller's labours gave the strongest impulse to the employment of the microscope in pathological investigation.

But in spite of all his zeal, pathology lay too remote for Müller.

1 Müller's Archiv. 1836. S. 176.

2 Rede zur Feier des 42 Stiftungsfestes des Kön. Med. Chir. Friedrich-Wilhelms-Institut. *Berlin*, 1836.

3 Ueber die feineren Bau und die Formen der Krankhaften Geschwülste. Erste Lieferung. *Berlin*, 1838.

4 De glandularum sec. structura. Præfatio, p. 3.

5 Ibid., p. 23.

He never succeeded in preparing a division of tumours; and he said that the principle of such a classification could not be solely based either on the fineness of their structure, or on their chemical composition, but that their physiological nature and curability must be taken into account. A scientific division—which must necessarily be anatomical or exact, and histological—was impossible, and Müller was puzzled, because even physiological histology could not afford a satisfactory classification. He therefore continued to read pathological works, but always with great disinclination; and it is certainly a significant fact, that when he died he left behind him nothing that was unprepared, unarranged, or incomplete, except the long-expected conclusion of his book on tumours.[1]

After the year 1839, we find him devoting himself exclusively to comparative anatomy. In 1841, he abandoned, for a short time, the vertebrate kingdom, and investigated pentacrinites[2] and star-fish.[3] Meanwhile, partly by accident and partly of necessity, he was led to see that the fossil world had not yet been fully explored: so he became a palæontologist, and studied fossil fishes, mammalia, and echinites;[4] and latterly paid individuals to be on the look-out for fossil remains in the quarries of the Eifel. But he once more felt himself specially attracted to the sea, in order to investigate its in-

[1] Perhaps it should be mentioned here that Müller expressly forbade any *post-mortem* examination of his body.

He took an interest in parasites for a short time after Schönlein's discovery of the nature of Favus; and he first found the *psorosperms*, which were afterwards made so remarkable by Lieberkühn's researches. *Archives*, 1841.

[These *psorosperms* occurred in the form of a peculiar morbid parasitic growth, with specific organised seminal corpuscles, which Müller first observed in the cellular tissue of the orbit of a young pike. This diseased growth consisted of delicate cysts, from $\frac{1}{5}$th to $\frac{1}{2}$ line in diameter, filled with a whitish substance, which was composed of small granules with molecular motion, and of motionless corpuscles with an oval body and tail, resembling spermatozoa. Müller considered it to be a curious instance of disease propagated by living *seminium morbi*, and to hold an intermediate place between the acknowledged parasitic entozoa and epizoa. See *Edin. Monthly Journ.*, July 1842. *Translator.*]

He also, in conjunction with Retzius, described the parasitic growths found in the respiratory passages of birds (*Archiv.*, 1842), the occurrence of which I have also demonstrated in man (*Virchow's Archiv.*, vol. ix., p. 557). He had at one time accurately investigated microcephalous skulls (*Med. Zeit. des Vereins. f. Heilk. in Preussen.* 1836), and the visit of the so-called "Aztecs" turned his attention again to this subject. This was the last pathological study which he undertook after his work on Osteoid Growths (*Archiv.* 1843).

[2] Ueber den Pentacrinus caput Medusæ (Akad. Abh. 1840–1). *Berlin*, 1843.

[3] J. Müller und F. H. Troschel. System der Asteriden. *Braunsweig*, 1842.

[4] Müller et L. Agassiz—Notice sur les vertèbres de squales vivans et fossiles. *Neuchatel*, 1834. Müller, Ueber die Fussknochen des fossilen Gürtelthieres, Glyptodon clavipes Owen. *Akad Abh.* 1847. Fossile Fische, gesammelt auf Middendorf's sibirischen Reise. *Leipzig*, 1848. Ueber die fossilen Reste der Zeuglodonten von Nord-America mit Rücksicht auf die europäischen Reste dieser Familie. *Berlin*, 1849. Ueber neue Echinodermen des Eifeler Kalkes. *Akad Abh.* 1856. Ueber einige Echinodermen der Rheinischen Grauwacke und des Eifeler Kalkes. *Akad. Monatsbericht März*, 1858.

ferior living inhabitants. The vacations became peculiarly seasons of hard work; he himself fished, and dragged out of the hidden depths of the ocean wholly new and unknown races of animals. He passed from one class of life to another; from sea-urchins and star-fish to infusoria and polycystines, whose varieties he was the first to describe.[1]

What a wonderful series of works! The whole kingdom of animal life and being lay spread out before him. Was he satisfied? Did he find repose in the investigations, which, ever since the catastrophe which befell him at Bonn, he had unceasingly pursued? Alas, no! His aspect remained stern; two strong angry wrinkles lay between his eye-brows; and his dark glance seemed to penetrate into the far distance. He said he was as restless as the waves. He thought that for many years he had neglected botany; so he purchased large and expensive works to recommence its study. But he was not any more composed in his mind. Ever fresh forms of life, but no connecting bond; ever new ideas, but no development of substance: What a painful riddle to solve!

Two northern *savans*,—first Sars, and afterwards Steenstrup,—showed a new mode of propagation among the lower animals, by means of alternate generation. The child did not resemble the father or mother; nor was the grandchild, in turn, like the child. Müller enthusiastically followed out this new track: he found that the same animal could propagate similar and dissimilar generations; and he also demonstrated, by a great number of new discoveries, the metamorphoses of the *Echinodermata*.[2] Honour and praise were heaped upon him, and his face wore a kindly smile.

And now, quite unexpectedly, and as sudden as lightning, new thoughts flashed into his mind, reviving old memories and the traditions of natural philosophy. "In the Bay of Muggia, near Trieste, there are found large numbers of the *Holothuria*, of the species *Synapta*."[3] Müller discovered great peculiarities in their germinal tubes (*Keimschlaüche*), which were internally connected with the vascular system, and in which ova, spermatozoa, and finally *young snails*, were developed. Snails in Holothuria! Müller became very excited at this discovery, and strove vigorously to grapple with the problem, which surpassed his comprehension. He wrote about it

[1] These labours chiefly occupied the last three years of his life. His last great work was "Ueber die Thalassicollen, Polycystinen, und Acanthometren des Mittelmeeres" (*Akad Abhaud.* 1856–58). Berlin, 1858. On the day before his death, he himself went to the zoological museum of Professor Peters, and obtained some *Polythalamacea*.

[2] Ueber die Larven und die Metamorphose der Ophiuren und Seeigel (Akad Abh. 1846). *Berlin*, 1848. Zweite Abtheil. *Berlin*, 1849. Ueber den allgemeinen Plan in der Entwickelung der Echinodermen (Akad. Abh. 1852). *Berlin*, 1853. Ueber den Bau der Echinodermen (Akad. Abh. 1853). *Berlin*, 1854.

[3] Ueber die Erzeugung von Schnecken in Holothurien. *Archiv. f. Anat. Phys. und Wiss. Med.* 1852.

as calmly as he could; but there was an under-current of bewildered excitement on the subject. Was this an alternation of generation? Can snails beget worms, and worms in return beget snails? "It will amply reward us," says he,[1] "briefly to examine the various probabilities. The alternative is, that the snail-begetting tube is itself an animal, or that it is an organ of the *Holothuria;* and, in either of these cases, we have to deal with a most extraordinary phenonemon. If this tube is an animal—a worm—not begotten by the *Holothuria*, but proceeding out of a snail, we have to deal with a wholly unlooked-for case of alternate generation; but still we could all the sooner explain and understand the marvel. But if there be no alternation of generation, but rather a metamorphosis instead, then the snails become transformed into a parasitic living worm, which again brings forth snails,—a wholly unexpected, but yet not irrational condition. If, however, the snail is a worm, begotten by the *Holothuria*, then the matter is still more wonderful and incomprehensible, and far surpasses all the known conditions of alternate generation. But if the tube is neither an animal nor worm, but an extraordinary organ of the *Holothuria*, then it is wholly inexplicable; and the inexplicable must then become itself the exponent of other similar things in nature, or, in other words, a fundamental fact. The entrance of new animals of various kinds into the world, at different stages of creation, is rendered certain by the facts of palæontology; but it must remain a supernatural fact so long as the occurrence of this entrance has not been actually seen or made patent to our observation. So soon as this becomes possible, the supernatural will cease, and a higher series of phenomena will enter into the order of the universe, for which observation will eventually discover laws. Like Gottfried's shield, which broke the spell of Armida's sorcery, the buckler of alternate generation and metamorphosis must be resolutely opposed to all the visible magic of nature, so long as there is any hope of victory. As far as the last and most extreme alternative is concerned, every one knows what may be said against it. As yet we know of no single reliable case in which primitive generation has been seen in the actual world, either in organic or inorganic bodies; and many regard it as quite certain that all the creation or creations of the world have been preceded by others. This is entirely opposed to the results obtained by the painstaking observations of Philippi on the tertiary and actual molluscous Fauna of Lower Italy, which indicate that the transition from the tertiary period to the present has taken place quite gradually, and without the occurrence of any great revolution to mark the division; but that rather, in this transition-process, individual species became extinct by degrees, and that others came in their place until we arrived at the present Fauna. That, in the present instance,

[1] Ueber die Erzeugung von Schnecken in Holothurien. *Archiv. f. Anat. Phys. und Wiss. Med.* 1852.

we have to deal with a conchilious animal, only heightens its incomparable interest, which connects this case with the weightiest questions in zoology, physiology, and geology. Unfortunately I must leave the subject, in the midst of all our longings, as an unparalleled instance of intricate perplexity, without having arrived at any conclusion; and I turn from it to the consideration of the contradictions and vacillating ambiguities of perceptions in general."

The expectation and the problem both remained; and Müller was quite in despair. He said he *must* solve the problem; and when he failed in this, when all labour was useless, and he should have been composed, he fell back on himself exhausted, sad, and discontented.

Now evil days came over him. The Revolution of 1848 occurred when he was the head of this University; this hall was the head-quarters of the armed student-corps during his Rectorate; and the noise of conflicting parties raged around these walls. But Müller was no politician; he depended on the judgment of others, and on his own prejudices, and was opposed to action. He and I were at that time on different sides; but this never lessened the esteem which we entertained for each other. Müller, as a Rector, was an impartial man, not the adherent of any particular party. He resigned the shattered sceptre of his rule as Rector, and retired to the sea-coast; but a residence there did not reinvigorate him as usual.

Several years afterwards occurred that dreadful shipwreck on the Norwegian coast, the story of which has been so often related; and the horrors of which none could tell so vividly as he, who then made such a narrow escape. The protracted danger of death, the loss of his accomplished pupils, and of so many helpless companions, all bowed down his spirit. He became timid, and thenceforth was afraid of the sea; yet it always attracted him again to its shores,—and he had no repose, no holidays or recreation. His toils became still greater; and once, when exhausted by one of his last labours, he exclaimed, in a sorrowful tone:—"My work is stained with my blood."

His health now began to fail; his disposition became wayward and capricious; he was irritable; and complained of pains in the head, and sleepless nights. A presentiment of death overshadowed him. He arranged all his affairs, private and public; he telegraphed to Cologne for his son; he appointed the next day for a consultation upon himself, and—when the morning of the 28th of April came, his wife found him lying a corpse!

The dark eye, which looked so stern when it was deep in investigations, and which laughed so brightly when he smiled, was now dim. The deep wrinkles on the face of the philosopher were now obliterated. The sturdy broad shoulders lay rigid for ever. And by the massive head—which seemed like that of some of the warriors of old—we perceived that a sublime mental worker had fallen.

Peace to his ashes!

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With the Author's Compts

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OBSERVATIONS

ON THE

GENETIC CYCLE IN ORGANIC NATURE,

AND

PARTICULARLY ON THE RELATION BETWEEN THE DIFFERENT FORMS OF ALTERNATION OF GENERATIONS AND THE MORE ORDINARY MODIFICATIONS OF THE REPRODUCTIVE PROCESS.

BY

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MDCCCLIX.

Observations on the Genetic Cycle in Organic Nature, and particularly on the Relation between the different Forms of Alternation of Generations and the more Ordinary Modifications of the Reproductive Process. By George Ogilvie, M.D., Lecturer on the Institutes of Medicine in Marischal College and University, Aberdeen.*

§ 1. *Origin of Organic Beings.*

The time is not yet out of mind when the doctrine of spontaneous generation was the great point of discussion in the physiology of reproduction. Now that this question has been set at rest by evidence as conclusive as any of a negative kind can well be, the attention of physiologists is chiefly directed to the relation between derivation in the ordinary way from two parents, and that other mode of origin from a single pre-existing form, of the prevalence of which among the lower species additional evidence is continually brought before us. In this mode of origin, which has received various names from authors, such as *Gemmation*, *Homogenesis*, and *Monogenesis*, a portion of the body of the parent becomes the seat of a certain independent manifestation of vitality, whereby the plastic processes are so much intensified that, in

* Read before the British Association for the Advancement of Science, September 1859.

the course of time, the part is converted into a distinct organism, capable of detachment from the parent, and fitted to maintain a separate existence. Such a detached gemma may be termed a free zooid, or phytoid. In the ordinary form of reproduction, again, that by the co-operation of the sexes, otherwise termed *Heterogenesis*, or *Digenesis*, a fusion takes place of two highly vitalized portions of the same or kindred organisms, and results in the formation of a fecundated germ, possessed henceforth of an independent vitality, endowed with a capacity for ultimately acquiring the structure characteristic of the species, and destined to be thrown on its own resources, by its extrusion from the protecting envelopes, as soon as its organisation is sufficiently advanced for this condition. In all but the very lowest forms of life, the conjugating algæ, a difference is observable between the two factors of embryonic life, which are recognised respectively as male and female, or as the spermatic and germinal elements.

§ 2. *Relations of Ova and Gemmæ.*

It is strongly contended by some that there is such an incompatibility between these two modes of propagation, that, in proportion as any portion of the parenchyma of the parent is engaged in the one course, it is proportionally disabled for the other. This opinion is founded on these alleged peculiarities of the sexual elements in their mature condition; 1*st*, That singly they are not capable of any farther development, but very soon lose their vitality, and undergo decomposition; and 2*d*, That they both differ very remarkably in appearance from all self-developing foci of vital action, and, in particular, that the germinal element of animals, or the unimpregnated ovum, though it may occasionally present a general resemblance to a gemma or bud, is always to be distinguished from it, by containing in its interior a peculiar nucleated cell, the germinal vesicle. But some, at least, of these peculiarities can no longer be maintained as constant characters. Quatrefages states that he has seen segmentation take place, independently of impregnation, in the ova of Hermella and Unio,

though no farther development follows. In regard to the structural characters, again, even putting aside the evidence concerning the germs of the viviparous aphides as somewhat discordant, though, certainly, on the whole, in favour of the essential identity of ova and gemmæ, the observations of Mr Lubbock on the agamic ova of Daphnia, and those of Mr Smith of Kew, Professor Braun of Berlin, Radlkofer, and others, on the unimpregnated ovules of Cœlobogyne, appear conclusive to establish that bodies elaborated side by side with the true germinal elements, and in some cases undistinguishable from them in appearance, may undergo development independently of impregnation; while those of Dzierzon and Siebold on the hive-bee, go to show that the very same germs may undergo evolution either with or without impregnation, developing, in the former case, a female, and in the latter a male progeny. We can hardly, therefore, as it would seem, avoid adopting Professor Owen's conclusion, that there is no *essential* difference between an ovum and a gemma, and that the one may pass into the other by insensible gradations. We may assume, perhaps, that up to a certain point, the development of the new focus of vital action may go on all the same for a gemma or an ovum; but that towards the period of maturation the changes which take place in the latter to fit it for impregnation cause such a tension, as it were, of its vitality, as is incompatible with its continuance in the majority of cases, unless re-invigorated by the access of the spermatic element.

§ 3. *Alternation of Generations.*

Propagation by gemmation has been regarded as perpetuating the individual rather than the species, the successive zooids or phytoids preserving more completely than the progeny of embryonic origin the characters of the parent stock; and it has been thought, too, that there is a tendency for the plastic power to wear out, in process of time, so that a recurrence of sexual generation at intervals is necessary to preserve the pristine vigour of the species.

However this may be, there is reason to believe that the

more highly organized the species is, the more dependent it is on the frequent recurrence of sexual reproduction in the genetic cycle. At least, we find that in the lowest forms there may be a very prolonged pullulation of gemmæ, the sexual act recurring only at distant intervals, and in some cases not being as yet positively known to occur at all; while in the higher animals we meet with no obvious phenomena at all of the nature of gemmation. In those of the lower species in which both modes of propagation are well-marked features, we find that they have a tendency to succeed each other in a regular order, with corresponding differences in the immediate progeny, to which the term of alternation of generations has been applied; and this expression, though open to some objections, has come into very general use.

A complete parallelism, however, cannot be maintained for all the cases that go under this name; and as I am not aware of any systematic analysis having been made, to determine the nature of the differences, it is my object on the present occasion to bring forward certain distinctions which have impressed themselves on my mind as of fundamental importance, depending principally on the period in the life-history of the species, at which a process of gemmation is interpolated in the genetic cycle.

The gemmation sometimes occurs just before, and is, as it were, ancillary to sexual reproduction—sometimes it occurs after it, when it is subservient rather to the progress of development. In the former case, what may, on the whole, be considered as the most typical of the diverse forms belonging to the species, is still defective in having no proper organs of reproduction—a function which is vicariously performed by a set of gemmæ detached from it. The original stock is really neuter; but true sexes appear in these buds, after they have been transformed by a process of development into isolated zooids or phytoids. They may be considered as a highly individualized form of those organs which were wanting in the parent stock. Such organs constitute, at least, the essential part of their economy; and although, along with them, there may be present also others, more or less fully developed, for

discharging functions, such as alimentation and locomotion, required by their status as free zooids, yet their great office is reproduction, and this end effected, their life speedily comes to a close. In this they contrast strikingly with the stock from which they were derived; for it is endowed with much greater permanence of life, frequently detaching during its period of vigour many successive swarms of sexual zooids, just as among the higher animals the same parent may develope many successive broods of young.

On the other hand, when the budding process occurs in the course of development, the gemmæ are detached from the immediate product of impregnation, while it is still in a rudimentary condition, comparable to the first stage in the evolution of the ovum of the higher animals. The germ-parent never itself attains to the full development of the species, but remains the whole term of its brief existence in a rudimentary state; but the progeny, which it buds off, acquire, in due course, the typical form, or at least give origin, mediately or immediately, to others which do so.

These two kinds of zooids, however, though differing so widely in their relations and structure—in the one case the primary products of impregnation, the precursors of the perfect form, and without sexual characters, in the other derivative and with distinct sexes—have yet this one point in common, that the great end of their existence is the multiplication of the race—an end to which the nutritive and animal functions are always subordinated. Such, indeed, is the occasional degradation or non-development of structure, that some zooids of both kinds might readily pass for mere egg-sacs or proliferous cysts.

§ 4. *Protomorphic Alternation.*

For the better distinction of these varieties of alternation, and for the purpose of bringing out more clearly what I consider to be their points of correspondence with phenomena occurring in the higher animals, I have found it convenient to divide the life-history of an organic being into three stages,

all of which come out prominently in one form of alternation or other, while, as I shall presently endeavour to show, they are covertly represented even in those species, in which no phenomena of alternation are recognised. The first, or what I term the *Protomorphic* stage, is that which intervenes between the fecundation of the germ and the first appearance of the characteristic or typical organisation of the species; the second, or *Orthomorphic*, that which corresponds to the development and full perfection of this organisation; while the third, or *Gamomorphic*, is that of the formation or maturation of those structures in which the spermatic and germinal elements are generated, in preparation for another act of fecundation, as the commencement of a new genetic cycle.

In one of the forms of alternation just noticed, the interpolation of gemmation takes place in the protomorphic stage—that is, prior to that development, by which the features most characteristic of the species are gradually evolved. Of this we have an example in the case of the Trematode Entozoa, so often referred to by writers on the subject of alternation. In these animals the immediate product of the impregnated ovum is a free zooid, which never rises itself above a rudimentary condition, or acquires sexual organs, but which, by a process of asexual gemmation (*monogenesis*), ultimately originates others, which do attain to the typical character of the species, in the general organisation, and commonly also in the sexual relations, and then propagate in the manner of the higher orders.

For another illustration, we may turn to an allied family, the Cystic Entozoa, now known to be merely rudimentary forms of Cestoid worms. Their transformation into the latter is their most notable change, but, prior to it, they present us with a series of successive forms, all referable to the cystic phase. The typical form is the "Tænia-head," which is not the immediate product of impregnation, but is derived as a gemma from the primary cyst, into which the contents of the ovum are first developed. With great differences of detail, this general relation is to be traced in all the species. Thus, in the *Echinococcus hominis*, a vesicular mass is formed from

the primary cyst, by the pullulation from its interior of secondary and tertiary structures of a like kind. Numerous gemmæ are developed from the last-formed cysts, having the general characters of "Tænia-heads." In another species or variety of *Echinococcus*, similar "Tænia-heads" are formed, in connection with vesicles budded off from the interior of the primary cyst, without the intermediate pullulation of other cysts. In *Cœnurus*, also, there is a formation of a multitude of "Tænia-heads" from the original cyst, only they are budded off from a special thickening of the lining membrane —not as in *Echinococcus*, from its whole interior.

The Echinodermata might also be cited in illustration, though they differ from the generality of cases of alternation, in the primary form budding off but a single secondary one.

As an example of protomorphic alternation in the vegetable kingdom, the case of the mosses may be referred to. Impregnation is now admitted to be as necessary a step in the reproduction of these as of any phanerogamic plants, but it is not the immediate precursor of the formation of an embryo. In mosses, the germinal element is represented by the central cell of the archegonium; and this, when fecundated by the spermatic filaments contained in the cellules of the antheridium, developes by endogenous formation a whole mass of cells, which, by a process of transformation in the course of growth, assumes eventually the form of the theca or capsule, with seta, calyptra, operculum, peristome, columella, and internal mass of dust-like spores. The spores in germination give rise to confervoid threads, which, after ramifying into a mass of tangled filaments—the protonema—send up here and there a leafy axis, bearing eventually, like the original one, antheridia and archegonia. In thus regarding the case of the mosses as parallel to that of the Trematoda, and illustrative of protomorphic alternation, of course I look upon the nascent axis as the true embryo, and the fully-developed moss as the typical form, and regard both the theca and the protonema as intermediate forms, no more represented in the higher plants, than the gregariniform zooids of distoma are in the higher grades of animal life.

§ 5. *Gamomorphic Alternation.*

The other form of alternation, before referred to, is that in which the process of gemmation is interpolated in what has been here termed the *gamomorphic stage, i.e.*, after the general acquisition of the typical conformation of the species, and in connection with the development of the organs which form the sexual elements. To this head I refer the alternation of polype and medusa forms, which is so common a feature in the life-history of the hydraform zoophytes, the normal or typical form being assumed to be that of the polype, and the medusa form being regarded simply as a highly individualized generative organ detached from the system of the polype. This view readily enough commends itself to our judgment in those species of *Laomedea*, &c., in which the medusiform zooids have so much the character of mere generative appendages, while the zoophyte condition stands prominently forward as the typical or orthomorphic phase, being represented by structures of greater permanence than the brood of minute and rudimentary medusoids which they throw off, and occasionally attaining considerable dimensions by the repeated pullulation of new polypes. But in the case of the Hood-eyed Medusæ, the *primâ facie* aspect of the case is entirely the other way ; for not only are they themselves of much more conspicuous dimensions and elaborate organisation than the medusoids of the compound zoophytes just referred to, but the polype stock from which they spring is of such insignificant proportions, that it generally goes under the name of a larva, the resulting medusæ being regarded as the typical or perfect form of the species. Thus, Professor Owen remarks, "The medusiform ovigerous locomotive or distributive individual of the *Coryne* and *Campanularia geniculata* is evidently homologous with the polypiform ovigerous individual, which seems to nurse, as it were, the ova into 'planulæ' in the *Campanularia dichotoma*, and the nutritive gemmiparous polypiform individuals in all the compound Radiarics would seem, rather than the oviparous medusiform ones, to manifest the typical form of the species. . . . Superadd, however,

distinct nutritive and circulating organs to the free moving ovigerous individual from the rooted polype, and prolong its existence, and it would then cease to have the ancillary character of a nurse to the ova of the fixed individuals, and would assume that of the perfected form of the species; and such, in fact, is the case with the larger gelatinous Radiaries, called *Medusæ*."* Now, in so far as perfection means elaborateness of organisation, it is not, of course, to be denied that the medusa is in advance of the polype; but as regards the selection of the phase to be taken as the typical form of the species, I do not see how we can avoid these conclusions:—1*st*, That the bare-eyed medusoids are really homologues of the parts of reproduction, inasmuch as they pass by a continuous gradation into generative organs of the simplest kind and, 2*d*, that in so natural an order, the relative position assumed for the puny bare-eyed Medusæ must hold also for their portly brethren of the hood-eyed kind.

My limits prevent me giving anything like a detailed view of the declension referred to from free medusoids to simple tunicated ova attached to the body of the parent; but the following may be noticed as observable links in the series.† In *Campanularia dichotoma*, the medusoids are no longer free as in *C. geniculata;* they have also more of the polype-form, and remain during their brief period of life attached to the edge of the horny "ovigerous capsule," characteristic of the zoophyte, and there emit the ova or spermatozoa with which they are charged; after which they wither away like blossoms, to be succeeded by a new expansion. In *Campanularia lacerata*, the ovarian sac advances to the mouth of the capsule; but, instead of a bell-shaped envelope, becomes invested merely by a thick gelatinous coat. In *Sertularia* generally, the appendages, with somewhat of the medusoid conformation, mature and discharge their contents while still within the "ovigerous capsule." In *Cordylophora*, the only medusoid features presented either by the spermatic or the ovarian cyst, are the presence of a central tongue or colu-

* Parthenogenesis, p. 12.

† See several papers by Dr T. S. Wright in previous numbers of this Journal.

mella to represent the proboscidiform mouth, and the existence of phlebenteric canals in its wall. In *Hydractinia*, we have the columella without the canals; and the cysts of some species of *Plumularia* and *Eudendrium* are, if possible, of still simpler structure, the latter containing but a single ovum. The progress of degradation reaches its maximum in the common *Hydra*, in which the large *Medusæ* of the "*Hydra tuba*" are represented only by spermatic and ovarian cysts, of the most rudimentary organisation, attached to the exterior of the polype. Closely allied species sometimes differ remarkably in this respect; and even in the same species there may be as great a diversity in the opposite sexes; thus in *Laomedea geniculata*, the ova are formed in free swimming medusoids; the spermatozoa in simple cysts permanently attached. Variations of the same kind occur also in the allied order of Physograda. Such variations, though perplexing to the systematic zoologist, are especially valuable to the physiologist, as indicating the true relations of the forms which occur in dimorphous species; and I think they are fully sufficient to bear us out in the conclusion, that both the bare-eyed and the hood-eyed Medusæ are to be considered as gamomorphic zooids, and the polype stock from which they sprang as the typical form in each case. In the one, the orthomorphic form is, as usual, the most conspicuous phase of the species, while in the other it is quite eclipsed by the resulting gamomorphic zooid, which is really a part of itself—a detached and overgrown organ of its own system.

As parallel cases, I would refer to the relation subsisting between the solitary and catenated *Salpæ*, which, as described first by Chamisso, may be regarded as the original basis of the doctrine of alternation, and of which Mr Huxley has since given us a most lucid and philosophical account—to the detachment of reproductive zooids, made up of caudal segments, budded off from some Annelida, as described by MM. Edwards and Quatrefages—and to the derivation from the "Tænia-head" of the *proglottides*, or cucurbitiform segments of the "body" of the tape-worm.

In the vegetable kingdom we have also a very parallel case in

the reproduction of the ferns. In these plants, it is well known the sexual elements are not formed in connection with the conspicuous vegetative stem, but in minute derivative phytoids, termed prothallia, which are produced by the germination of the spores. The prothallia bear antheridia and archegonia; and the embryo, formed on impregnation from the central cell of one of the latter structures, grows up from the prothallium, which comes to have very much the appearance of the seed-leaf of the young shoot. The prothallia I regard as gamomorphic phytoids, parallel to the medusiform reproductive zooids of the Polypifera. Hence I feel obliged to dissent from the parallelism which Hoffmeister would establish between the reproductive process in ferns and mosses. This great authority regards as equivalent structures the prothallium of the former and the leafy axis of the latter, on the ground of their being the parts which bear the sexual organ; and argues from this a corresponding relation between the frondiferous stem of the fern and the seta and capsule of the moss, as the immediate products of impregnation in the two cases respectively. A comparison of objects of such *primâ facie* diversity—objects more unlike than even the large *Medusæ* and the ovarian cysts of the *Hydra*—ought not, I conceive, to be adopted, except on the most convincing evidence. But there is no such cogency in this case, on the admission of the general view which has now been advanced; for we have a readier solution of the difficulty, in assuming that the interpolation of an intermediate form occurs at a later stage of the genetic cycle in ferns than in mosses. For this view we have ample warrant in the analogy of the animal kingdom, where we find corresponding differences between the Cestoid and Trematode Entozoa, and between the latter and the Polypifera, among which, indeed, even nearly allied species differ in this matter of the interpolation of gemmation. Such a view, I submit, is a less tax on our powers of conception, than to regard the minute and fugitive capsule of the moss as the equivalent of the perennial and towering stem of the tree-fern. And it is to be borne in mind that the difference here is not merely one of a *primâ facie* kind. In some respects it increases the more we con-

template it; for it is clear, as Mr Jenner observes,* that the persistent character of the leafy axis of the moss, and its yielding, in perennial species, many successive sets of sporiferous capsules, assimilates it, quite independently of structural features, rather to the stem of the fern than to its prothallium, which is an organ even more evanescent than the capsule of the moss, its existence terminating when the embryo formed in it has begun to germinate.

§ 6. *Orthomorphic Alternation.*

In the intermediate period of the life-history of the species, that here termed *orthomorphic*, which intervenes between the appearance of the general typical character of the family and the maturation of sexual organs, gemmation, though perhaps a more frequent character than either in the incipient or terminal stages, rarely comes before us as a case of alternation of generations, in consequence of the gemmæ commonly remaining in adhesion to each other, so that their separate individuality is lost, and the whole aggregation passes as a single plant or animal. This is especially the characteristic arrangement in the vegetable kingdom, and in Polypifera and Polyzoa among animals. Where the gemmæ do become detached, however, the case may assume the aspect of a form of alternation, as we see strikingly exhibited in the propagation of the *Aphides*.

I may here briefly explain why I am disposed to refer the alternation of the *Aphides* to the commencement of this stage, rather than to the protomorphic. It is because the organisation has already acquired that partially advanced development characteristic of the larvæ of other insects, before the process of gemmation comes into play. We cannot say here that the primary product of impregnation buds off a set of embryos of a higher organisation; it is rather a larva—that is, a

* Edin. New Phil. Jour., New Series, Vol. III., p. 269. The occasional conversion of the fruit of the moss into a leafy shoot has been thought to indicate its analogy to the stem of the fern. Is it not rather a viviparous inflorescence, such as occurs at times in the higher plants?

naked embryo—already so far organised on the insect type, that buds off a series of similar larvæ, the last only of which become perfect insects.

§ 7. *Resumé of the Varieties of Alternation.*

On the grounds above stated, it becomes necessary to distinguish these three varieties of the so-called alternation of generations,—that is, of the alternation of gemmation with sexual reproduction :—

1. That in which the gemmation occurs in the protomorphic or germinal stage, prior to the appearance of the typical organisation ;

2. That in which it occurs in the gamomorphic or later stage of the life-history,—that is, in connection with the maturation of the reproductive organs ; and,

3. That in which it occurs in the orthomorphic or intermediate stage,—that is, during the manifestation of a more fully developed condition of the typical organisation, but prior to the maturation of the sexual organs.

The contrast lies principally between the two former varieties. They cannot, indeed, be identified or confounded, as they are by many authors, without losing sight of two important points of difference ;—

1. In the budding-stock, which in gamomorphic alternation has both a higher organisation and a greater permanence of life than are possessed by the protomorphic zooid or germ-parent of the typical form ;

2. In the off-sets or concluding links of the respective series, which have really nothing in common but the single point of sexual completeness, the medusoids, prothallia, and other gamomorphic forms being generally of the most rudimentary structure.

Hence, in the one case, we speak of the typical organism and its germ-like matrix ; in the other, of the typical organism and its sexual offset. Both the matrix and the offset may assume, indeed, the form of independent beings, but their life is always transitory and provisional, having reference to

one common end,—the multiplication of the race,—though by different means. The great function of the germinal or protomorphic zooids is the evolution of the more perfect embryos, of which they serve as budding-stocks; that of the sexual or gamomorphic zooids is the development of ova and spermatozoa. These ends accomplished, their vitality ceases, while the typical organism, the offspring of the former class, or the parent stock of the latter, as the case may be, has a much more permanent duration, and may go on for a long time in perfect vigour, sending off crop after crop of ova, or of sexual gemmæ, according to its mode of propagation.

The distinctness of these varieties of alternation is further shown by their occasional co-existence in the same species, as in some Cestoid worms, and perhaps in a more latent form in the case of the Polyzoa* and of some Annelida. These, however, are exceptional cases, for it would appear that organisms which are propagated by protomorphic gemmation do not ordinarily throw off sexual zooids, and that species in which the latter phenomenon occurs do not usually furnish instances of proembryonic forms.

§ 8. *Continued Pullulation in the same stage.*

The regularity in the alternation of free zooids with true embryos is frequently obscured in nature by the intervention of a process of *pullulation*, or budding off of like forms, in continued succession, at some particular stage in the life-history of the species, so that sexual zooids recur only at intervals, separated by periods during which a series of neuter forms occur of the same general character, if not all absolutely alike. In some cases, the number of interpolated links appears to be fixed; but in general it is variable, and frequently the recurrence of the sexual form which closes the series seems to depend on circumstances, the true ova being commonly formed on the approach of winter, or other conditions adverse to the continuation of active vitality.

* Allman's British Fresh-water Polyzoa (Ray Soc.), p. 41.

A course of pullulation may be thus interpolated at any stage. It is met with in the germinal stage in the case of the Trematoda, and in the gamomorphic or sexual stage in a few medusoids; but more commonly it occurs in the orthomorphic stage, being interposed between the first appearance of the typical characters, and the development of the structures which originate the sexual elements. In fact, the orthomorphic gemmation, just noticed as one form of alternation, almost always runs on into a continued course of pullulation, the result being either a swarm of free zooids, as in the case of the *Aphides,* or else a composite structure, like the leafy stem of a plant, or the polypidom of a zoophyte. The latter alternative is the more common; for the tendency of the gemmæ, in most cases of continued pullulation, is to remain during their whole term of life in connection with the parent stock, either directly, or through the medium of their predecessors in the series of offshoots.*

§ 9. *Protomorphic Alternation in relation to Embryogeny.*

Though the well-marked cases of alternation, due to the evolution of protomorphic zooids, are confined to a few of the lower orders, a certain *nisus* or tendency in this direction—a fresh start, as it were, in the course of germinal development—may be traced with more or less distinctness in all cases of embryogeny, as in all instances there is formed first a cellular germ-mass, from one point of which there is subsequently developed a new axis of embryonic growth.

The embryo, in short, may be said to be budded off from the primordial germ-mass, much as the larval distoma is from the gregariniform product of the Trematode ovum. There are, however, two points of diversity. In normal development, the germ-mass gives rise only to a single embryo, and no separation takes place between them. The later growth appears simply as a more advanced state of the former, which wastes

* In the tabular views of the Genetic Cycle, given at the end of this article, such continued pullulation—as being only an occasional phenomenon—is printed in a smaller type.

away, *pari passu*, with the growth of the embryo, becoming a mere appendage of the latter, or disappearing altogether. In alternation or metagenesis, again, the immediate product of the ovum gives rise to *numerous* gemmæ, every one of which may acquire the characters of a typical individual of the species; and we find that these gemmæ generally become completely separated from their germ-parent, and assume the form of independent organisms. But although the detachment of the later growth, and its multiplication, give an apparent distinctness to the cases in which they occur, there are yet phenomena of an intermediate kind, which indicate a certain community of nature between them. Such are the following:—

1. The duplication, in whole or part, of the embryonic axis, as an occasional abnormality, even in the higher species, resulting in the formation of a double monster.

In the eggs of the pike, according to M. Lereboullet, "the formation of these monsters may be determined at pleasure, by placing the eggs in unfavourable conditions for development." In this case the blastodermic ridge forms on its surface two tubercles instead of one, and from each of these an embryonic fillet is produced, the further development of which gives rise to double embryos of various kinds.*

2. The regular formation of a double embryo from the ovum, in the case of the Polyzoa.

Here the immediate product is a ciliated germ-mass, like an infusorial animalcule, from a protrusion of which, according to Professor Allman, a pair of polypes are budded off in succession, the process presenting, as he observes, some remarkable analogies, tending to bring the whole process of gemmation and generation within the domain of the so-called "law of alternation of generations,"† though neither the two first-formed gemmæ, nor those which afterwards pullulate from them, ever become detached, while the original germ-mass becomes as completely reduced to the condition of a mere appendage of the

* An. Nat. Hist., 2d Series, xvi., 49.

† British Fresh-water Polyzoa (Ray Soc.), pp. 41, 33, 34.

structures derived from it, as in the case of the ovum of any vertebrated animal.

3. The variable character of the gemmation of Tænia-heads in the cystic Entozoa—solitary in the *Cysticercus*, but multiple in the case of the *Cœnurus* and *Echinococcus.**

4. The co-existence among the Echinodermata of cases resembling ordinary embryogeny, or the metamorphosis of insects, as in *Echinaster* or *Holothuria*, with others, constituting the majority of the class, in which the embryo, though still solitary, stands out as a distinct structure from the so-called larva, and has in so far the character of a derivative zooid.

The case, therefore, seems to stand thus. Embryonic gemmation may be said to occur in all cases, though in the higher animals only in a latent form; while in the lower species, it is so exaggerated as to acquire a wholly new character. So long as the exaggeration is merely in its distinctness, or in the more complete detachment of the gemma, the affinity of the process to the normal course of embryogeny is sufficiently apparent (as in the Echinodermata). Even when a new element of discrepancy is introduced by a multiple gemmation, we can still find a parallel in the embryogeny of the higher animals, though now only as an occasional abnormality. But when the breach is yet further widened by one or more repetitions of the process of gemmation, we have results so totally unlike the ordinary course of reproduction in the majority of animals, that it is with some difficulty we can realize any community between them.

§ 10. *Gamomorphic Alternation in relation to Sexual Maturation.*

As the appearance of a new centre of organisation in the cellular germ-mass may stand in the higher species as a representation of protomorphic alternation, so to the contrasted form—marked by the formation of sexual or gamomorphic

* An argument of all the greater cogency if Cœnurus be, as Siebold contends, a mere variety of Cysticercus. Even in admitted forms of Cysticercus, however, such multiple gemmation of Tænia-heads has been observed.

zooids—may we trace a certain correspondence in the maturation of the reproductive organs. Such a correspondence is suggested in particular by the following considerations :—

1. The periodicity and lateness of development of the organs of reproduction in most species, and their greater or less independence of the rest of the system in some cases. This is so much the case in the Polyzoa, that, in the opinion of competent judges, they hold the position rather of derivative gemmæ, than of mere organs of the particular polypes, in connection with which they are developed. Thus, Professor Allman remarks, "If the formation of the ovary be attended to, it will be seen that this body is developed at a later period from the walls of the original sac-like embryo, which have undergone slight changes, and have become the endocyst of the more mature polyzoon, and it will be at once perceived that this development of the ovary takes place in a way which may obviously be compared with the formation of a bud ; that—at least in *Alcyonella*—it occupies exactly the position in certain cells that the buds destined to become polypides [polypes] do in others, and that, at an early stage of polypide and ovary, it is scarcely possible to distinguish one from the other ; so that the idea is immediately suggested, that the body here called *ovary* is itself a distinct zooid, in which the whole organisation becomes so completely subordinate to the reproductive function as to be entirely masked and apparently replaced by the generative organs." On similar grounds he argues, that the spermatic organ "may perhaps be more correctly considered, like the ovary, as a distinct sexual bud, having the generative system so enormously predominant as to overrule and replace all the rest of the organisation ; this bud, like the ovary-bud, being also unisexual, but with a male function."

2. The transition in certain families, as the Polypifera, and even among closely allied species, from cases in which the reproductive organs are integral parts of the system and of very simple structure, to others in which they occur in detached zooids, having the character of distinct and well-organised animals.

3. The accidental nature of the characters which principally

distinguish these zooids from the ordinary organs of reproduction—detachment, and complexity of organisation.

The transition just noticed in the order of Polypifera is sufficient to show that differences in these points cannot be allowed any weight in a question of this kind. In regard particularly to what may be termed the adventitious organisation of the reproductive zooids, as compared with mere organs fulfilling the same function, this conclusion is strengthened by the contrast of a phenomenon of an opposite kind,—the degradation of individuals in certain species to the position of mere sexual mechanisms, these individuals being truly distinct from their origin—not mere zooids budded off from other forms, but animals developed independently from impregnated ova. The males of certain Rotifera, and still more those in the Cirripedia which are termed parasitic or complementary, are examples in point. In the structures now contrasted, we have examples of the two extremes of organisation; in the one case we have a *member* organised above par, so as to simulate a complete animal; in the other we have a true *animal*, so far below par in its structural development, as to resemble a mere organ. The contrast shows in a striking way that the suppression of normal parts in an animal, or the development of adventitious structures in connection with any particular organ, are not of essential importance in determining what has been termed by some authors "zoological individuality."

The other character—that of detachment—hinges on the proportionate development of the *somatic* life, that is, the life of the body as one whole, and the more or less independent life of its several organs or what we may term the *topical* or regional life. In the higher animals, the special actions of the several organs are as completely subordinated to that of the body as a whole, as are the powers of local corporations to the central government in any well-ordered state; yet there still remains sufficient evidence of the real existence of a distinct topical life. The antlers of the deer, and the hairs and teeth of animals generally, furnish well-marked illustrations of it. The first set of teeth, for instance, are formed, each in its own capsule, by a process of local growth, quite independent

of that of the neighbouring tissues, nay, in so far opposed to it, that, at a certain stage of development, the integuments of the gum are partially disintegrated to allow of their eruption. A tooth thus generated by independent growth, sometime after attaining maturity, undergoes a process of decay ending in its ultimate removal, when a new tooth, of the second dentition, takes its place by a similar process of local development. In its turn this tooth also is shed, and though in most species it has no successor, yet in a few there is a constant succession during the whole lifetime of the animal. Such also is the case with the growth of the hair in all species. Hence in such local formations as teeth, hair, &c., we have, both in the way in which they are marked off from the neighbouring parts, and in this succession of growth, maturation, and decay—repeated again and again, and epitomizing, as it were, the life of the animal on which they grow—evidence of a vitality quite as defined perhaps in itself as that presented by the free zooids of the lower species, though the functional dependence on the common circulation and the mechanical bond of a common integument prevent their exhibiting the more obvious phenomena of a separate life. But as we descend in the scale of organisation, we come to species where, from the absence of centralising influences, the several organs—which are possessed of a vitality, less energetic perhaps, but more enduring than in the higher—become emancipated, as it were, from the control of the general system, and appear as zooids, that is, in the guise of independent beings, rather than as integral parts of the same animal—suggesting the similitude of the feudal system of the middle ages, or of a loose confederation of Indian tribes, rather than of a well-ordered polity of our own day. And though the proper organs of reproduction, from their partial independence even in the higher animals, seem, as we might expect, to manifest most clearly this emancipation from the controlling influence of somatic life, yet it is seen very distinctly in others also, as, for instance, in the peculiarly modified tentacle of the *Argonauta*, which, when filled with spermatic fluid, is detached from the body, and finds its way spontaneously to the female, for the purpose of impregnation.

4. In the vegetable kingdom the correspondence of the archegonia formed in the prothallia or detached reproductive phytoids of ferns, to the intra-ovular structures of flowering plants, furnishes also an analogical argument of great weight in support of an essential community of nature between the proper organs of reproduction, and all such isolated gamomorphic forms, whether of the vegetable or the animal kingdom. This correspondence has been most satisfactorily traced by Hoffmeister and others, through the intermediate orders of Lycopodiaceæ, Marsileaceæ, and Coniferæ; but I need not make farther allusion to a subject on which I have nothing new to bring forward, and which, in any case, could not be fairly treated in the limits of this paper.

It formed part of my original plan, to make a few observations on the relations of metamorphosis to alternation or metagenesis, and to follow up these general statements with some remarks on the principal modifications of the reproductive process in the leading groups of both kingdoms of nature, with the view of showing how far the protomorphic, orthomorphic, and gamomorphic stages are represented both in the alternating and non-alternating species; but the extent of my first draught of the subject has shown me how impracticable this would be within the limits of such an article as the present. In the meantime, therefore, I must content myself with such indications of these relations as are suggested by the annexed tabular views to which I have had occasion to direct attention in the course of this paper.*

* It is only since these remarks were sent to press that I have seen Radlkofer's observations on the function of reproduction in the animal and vegetable kingdoms. In the latter, this author distinguishes very clearly the varieties of alternation here termed Protomorphie and Gamomorphie, but in animals he seems only to recognise the first, so far, at least, as I can understand the translation of his paper in the "Annals of Natural History" (2d series, vol. xx., pp. 241, 344, 439).

Table I.

Table I.

GENETIC CYCLE IN ANIMALS.

ALTERNATION OF GENERATIONS. | ORDINARY REPRODUCTION.

PROTOMORPHIC STAGE.

Primary Development from the Ovum,

of a Protomorphic Zooid,—*e.g.* in *Echinodermata*—of *Auricularia, Bipinnaria, Pluteus;* in *Cestoidea*—of Cystic Forms; in *Trematoda*—of Infusorian, and Gregarinic Forms.	of the Cellular Germ-Mass or "Mulberry Body."
Pullulation of Derivative Protomorphic Zooids, as in *Echinococcus*, some *Trematoda*, &c.	

Formation of "Embryo-Buds," e.g.,

of the Disc of the *Echinodermata*, or the Cercariform Embryos of the *Trematoda*.	of the "Primitive Trace" of Embryonic Organization.

ORTHOMORPHIC STAGE.

Development of the Typical Form,

as, in *Echinodermata*, of the Starfish or Sea Urchin; in *Cestoidea*, of the "Tænia-head;" in *Trematoda*, of the Cercariform Larva and the *Distoma*.	through the successive phases of Embryogeny; (Metamorphosis in the case of Larvæ or Naked Embryos, as in some *Crustacea, Insects*, and *Batrachia*.)
Pullulation in *Polypifera* and *Polyzoa*, of a series of Polypes cohering as a Polypidom; in *Aphis*, of successive swarms of free Larvæ, like the original.	

Formation of "Brood-Stocks," e.g.,

The "Gonophores and Blasto-styles" of the *Polypifera;* The "Stolons" of the *Tunicata*.	The Tissue of the immature Ovarian and Spermatic Glands.

GAMOMORPHIC STAGE.

Development of the proper Reproductive Structures,

As in *Polypifera*, of Medusiform Zooids in *Salpa*, of the Catenated Form; in *Annelida*, of Caudal Zooids; in *Cestoidea*, of Proglottides.	as of Ovarian and Spermatic Follicles.
Pullulation of Secondary Medusoids in *Sarsia* and some other Species.	

Formation of the Reproductive Elements, i.e., Ova and Cells with Spermatozoa.

FECUNDATION OF THE OVUM.

Table II.

GENETIC CYCLE IN PLANTS.

CRYPTOGAMIA.	PHANEROGAMIA.
PROTOMORPHIC STAGE.	
Primary Development from the Fecundated Germ	
in *Hepaticæ* and *Mosses*, of the Theca, and Spores, which in the latter germinate into Protonemic Filaments	of the Cellular Pro-embryo or Suspensor.
Pullulation of Derivative Protonemic Filaments;	Quaternate division of the Suspensor in *Coniferæ*.
Formation of "Embryo-Buds," viz.:	
the Gemma of the leafy axis of *Mosses*;	the Embryonic Cellular Mass.
ORTHOMORPHIC STAGE.	
Development of the Typical Form or Vegetative Axis of the	
Moss, *Fern*, or	Flowering Plant.
Pullulation of Successive Shoots, generally remaining in adhesion, but sometimes developed from deciduous bulbs.	
Formation of "Brood-Stocks," viz.:	
Perichætia of *Mosses*, Sporangia and Spores of *Ferns*;	The Floral Organs.
GAMOMORPHIC STAGE.	
Development of the proper Reproductive Structures, viz.:	
in *Ferns*, of Prothallial Phytoids;	of Ovules and Pollen-grains.
Pullulation of occasional Secondary Prothallia in *Ferns*;	and of the "albuminous bodies" in *Coniferæ*.
Formation of the Reproductive Elements, viz.	
of Archegonia, with Germ-cells and Antheridia, with Cellules containing Antherozoids	of Embryo-sacs with Germinal Bodies and Pollen-tubes with Fovilla (or in some *Coniferæ*, with Secondary Cellules).

FECUNDATION.

Table III.

PERIODS OF INTERPOLATION OF GEMMATION

IN THE GENETIC CYCLE.

PROTOMORPHIC.	ORTHOMORPHIC.	GAMOMORPHIC.
Mosses and Hepaticæ	Plants of all Classes.	Ferns and Equiseta
Echinodermata	Polypifera	Polypifera
(Polyzoa)	Polyzoa	(Polyzoa) Salpæ
Trematoda		
Cestoidea		Cestoidea
(Annelida)		Annelida (*Syllis*, &c.)
	Aphides	

Gemmation is exceptional, in any stage, among the higher Articulata and Mollusca, and is unknown as a normal arrangement among Vertebrata.

Table IV.

RESTING PERIODS IN THE GENETIC CYCLE.

Mosses and Hepaticæ *protospores*	In the middle of the Protomorphic stage.
Ferns and Equiseta *gamospores*	Between the Orthomorphic and Gamomorphic.
Phanerogamia *seeds*	Between the Protomorphic (embryogeny) and the Orthomorphic (vegetation commencing with germination).

Coniferæ present also another resting period, in the middle of the Gamomorphio stage (during the maturation of the fruit).

Animals in general, *eggs* or *ova*,	Between the Gamomorphic (maturation of the reproductive organs) and the Protomorphic (embryogeny).
Insects, Trematoda, &c.	Have also a resting period (*pupa* or *encysted state*) during their metamorphosis, in the early part of the Orthomorphio stage.

Mammalia have no obvious resting period, the mature ova requiring immediate fecundation, which is at once followed by segmentation and the development of the embryo.

The bodies which, under the names of *statoblasts*, *bulbs*, *resting spores*, &c., perform the part of eggs or seeds in some species of animals and plants, appear occasionally to be gemmæ, which may be termed *accessory*, as lying out of the direct genetic cycle.

3

A GUIDE

TO THE

FOOD COLLECTION

IN THE

SOUTH KENSINGTON MUSEUM.

BY EDWIN LANKESTER, M.D., F.R.S.,

SUPERINTENDENT OF THE ANIMAL PRODUCT
AND FOOD COLLECTIONS.

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The Museum is open every day, and on Monday, Tuesday, and Wednesday evenings.

SCIENCE AND ART DEPARTMENT
OF THE COMMITTEE OF COUNCIL ON EDUCATION, SOUTH KENSINGTON.

REGULATIONS for the GUIDANCE of CONTRIBUTORS to the ANIMAL PRODUCTS and FOOD COLLECTIONS of the SOUTH KENSINGTON MUSEUM.

Superintendent, Dr. LANKESTER.

1. THE Museum will be open, FREE, on Mondays, Tuesdays, and Saturdays, in the daytime, and in the evenings of Mondays and Tuesdays. The Students' days are Wednesdays, Thursdays, and Fridays, and the evening of Wednesdays. The hours are from 10 till 4, 5, and 6, according to the season, in the daytime, and from 7 till 10 in the evening.

2. Contributions accepted for exhibition must be forwarded at the risk of the Contributors. The specimens will be classified and arranged by the officers of the Museum.

3. Descriptive labels will be attached to the various contributions, giving their names, uses, prices, &c.

4. It is desirable that the usual retail price should be distinctly marked on all articles sent for exhibition.

5. Objects admitted to the Museum cannot be removed (except under special circumstances, by written agreement) until they have been exhibited for a period of at least twelve months.

6. The exceptions to the foregoing regulation would be for articles of a perishable nature, and for such as may have become damaged by exposure or from other causes.

7. In order to protect the property of Exhibitors, no article will be allowed to be removed from the Museum without a written authority from the Keeper.

8. A Catalogue will, from time to time, be published, so as to keep pace as much as possible with the additions to, and the withdrawals from, the Museum.

9. Exhibitors desirous of advertising in the Catalogue may send their prospectuses, illustrations, price-lists, &c., 1,000 copies at a time, and printed in demy 8vo., so that they may be bound up in the Catalogue. The binding will be free of cost to Exhibitors.

10. All contributions forwarded to the Museum must be addressed to the Secretary of the Science and Art Department, South Kensington, care of Richard A. Thompson, Keeper of the Museum.

HENRY COLE, *Secretary*.

By order of the
Committee of Council on Education.

A GUIDE TO THE FOOD MUSEUM.

The original idea of the Food Museum, which is placed in the South Gallery, was suggested by Mr. Twining, as part of a plan for the establishment of an Economic Museum that should comprise illustrations of every-day life for the working classes. The Food Museum was for some time carried on under the direction of Dr. Lyon Playfair, and, as now constituted, has been arranged with the express object of teaching the nature and sources of the food which rich and poor alike need for the maintenance of their daily life. Although great progress has been made in carrying out this design, the collection is not yet in a condition to justify the publication of a catalogue, and this Guide is intended as an introduction to the general principles and plan upon which the Museum has been arranged. Two great objects have been kept in view in the collection:—First, to represent the chemical compositions of the various substances used as food; and, secondly, to illustrate the natural sources from which the various kinds of food have been obtained. Where the processes of the preparation of food admit of illustration, these are also exhibited.

There are many methods by which such a collection might be arranged, but the chemical composition of food has recently been discovered to have so close a connexion with its action on the system that it has been deemed advisable to follow a chemical arrangement. All food is found to be composed of the same materials or elements as the human body. The neccssity of the supply of food from day to day depends on the fact, that the elements of the human body are daily wasted by the processes of

life. As a fire cannot *burn* without a supply of *fuel*, neither can the human body *live* without its daily supplies of *food*.

COMPOSITION OF THE HUMAN BODY.

Not only does food supply the daily waste of the human body, but, as the body increases in size from birth to adult age, it is supplied with materials for this increase by the aid of food. In order, therefore, to understand the value of food from its composition, it is necessary to know the composition of the human body. Just as any other compound substance can be submitted to chemical analysis and the elements of which it consists ascertained, so can the composition of the human body be discovered. Such analyses of course become difficult in proportion to the complication of the body analysed, and only an approach to the true quantities in which the elements exist can be expected. In case No. 1, Division A, the results of such an analysis has been attempted, and the quantities of each element entering into the composition of a human body weighing 11 stones or 154 pounds is (as far as possible) presented to the eye.

The following are the elements and their quantities :—

Ultimate Elements of the Human Body.

	lbs.	oz.	grs.
1. *Oxygen*, a gas. The quantity contained in the body would occupy a space equal to 750 cubic feet - - -	111	0	0
2. *Hydrogen*, a gas. The lightest body in nature. The quantity present would occupy about 3,000 cubic feet - -	14	0	0
3. *Carbon*, a solid. When obtained from animals it is called animal charcoal	21	0	0
4. *Nitrogen*, a gas. It would occupy, when free, about 20 cubic feet - -	3	8	0
5. *Phosphorus*, a solid. This substance is so inflammable that it can only be kept in water - - - -	1	12	190

	lbs.	oz.	grs.
6. *Calcium*, a solid. The metallic base of lime which has not yet been obtained in sufficient quantity to be employed in the arts. It is about the density of aluminium - - - - - -	2	0	0
7. *Sulphur*, a solid. A well-known substance. It unites with hydrogen, forming sulphuretted hydrogen, which gives the unpleasant smell to decomposing animal and vegetable matter - -	0	2	219
8. *Fluorine*, a gas. This substance has not been separated in such a manner as to permit of an examination of its properties, and cannot be exhibited. It is found united with calcium in the bones -	0	2	0
9. *Chlorine*, a gas. When combined with sodium it forms common salt -	0	2	47
10. *Sodium*, a metal. It is so light that it floats on water, and is kept in naphtha to prevent its oxidation -	0	2	116
11. *Iron*, a metal. In small quantities it is necessary to the health of the body	0	0	100
12. *Potassium*, a metal. Like sodium it floats on water, and burns with a flame when placed on it - - -	0	0	290
13. *Magnesium*, a metal. Combined with oxygen it forms magnesia - -	0	0	12
14. *Silicon*, a metallic substance. With oxygen it forms silex or silica. It enters into the composition of the teeth and hair - - - - -	0	0	2
	154	0	0

Other elements have been found in the body, as copper and manganese, but these are probably accidental.

These elements, when combined together, form a set of compound bodies called "proximate principles," out of which the tissues and fluids of the body are formed.

Proximate Principles of the Human Body.

	lbs.	ozs.	grs.
1. *Water*, composed of oxygen and hydrogen gases - - -	111	0	0
2. *Gelatin*, of which the walls of the cells and many tissues of the body, as the skin and bones, are principally composed -	15	6	0
3. *Fat*, which constitutes the adipose tissue - - - - -	12	0	0
4. *Phosphate of Lime*, forming the principal part of the earthy matter of the bones - - - - -	5	13	0
5. *Carbonate of Lime*, also entering into the composition of bone - -	1	0	0
6. *Albumen*, found in the blood and nerves - - - - -	4	3	0
7. *Fibrine*, forming the muscles and the clot and globules of the blood - -	4	4	0
8. *Fluoride of Calcium*, found in the bones - - - - -	0	3	0
9. *Chloride of Sodium*, common salt -	0	3	376
10. *Sulphate of Soda* - -	0	1	170
11. *Carbonate of Soda* - - -	0	1	72
12. *Phosphate of Soda* - -	0	0	400
13. *Sulphate of Potash* - - -	0	0	400
14. *Peroxide of Iron* - - -	0	0	150
15. *Phosphate of Potash* - -	0	0	100
16. *Phosphate of Magnesia* - -	0	0	75
17. *Silica* - - - -	0	0	3
	154	0	0

These compounds, in passing away from the body, form many others, which may be here left out of consideration as not forming a necessary part of the fabric of the human body.

None of these constituents of the body remain permanently in the system, and whilst the old particles are being removed new ones are supplied by the food. It is calculated that in this way a quantity of material, equal to the weight of the whole body, is carried away every forty days. So

that we may be said to moult or cast away our old body and get a new one every forty days.

The materials for the food of man, and containing the above elements, are derived from the mineral, vegetable, and animal kingdoms. The vegetable kingdom, however, is the great source of food to man and animals, as it is in the cells of the plant that the elements undergo those chemical changes which fit them for food. The animal can only supply what it obtains from them, and the substances supplied by the animal kingdom as food are identical with those obtained from plants. To a certain extent the physiological action of food depends upon its chemical composition, and in the following Classification of Food, according to which the museum is arranged, this fact is recognized.

CLASSIFICATION OF FOOD.

CLASS I. ALIMENTARY OR NECESSARY.

Group 1. *Mineral:*

a, Water;
b, Salt;
c, Ashes of Plants and Animals.

Group 2. *Carbonaceous or Respiratory = Heat-giving:*

a, Starch;
b, Sugar;
c, Fat.

Group 3. *Nitrogenous or Nutritious = Flesh-forming:*

a, Albumen;
b, Fibrine;
c, Caseine.

CLASS II. MEDICINAL OR AUXILIARY.

Group 1. *Stimulants:*

a, Alcohol;
b, Volatile Oils.

Group 2. *Alteratives:*

a, Acids;
b, Alkaloids.

Group 3. *Narcotics:*
a, Tobacco;
b, Hemp;
c, Opium.

Group 4. *Accessories:*
a, Cellulose;
b, Gum;
c, Gelatine.

CLASS I. ALIMENTARY OR NECESSARY FOOD.

GROUP I. MINERAL FOOD.

Water.

The first and most essential constituent of food is Water. Three fourths of the body is composed of water, and it is by the agency of water that all kinds of food are taken up into the system. Solid food contains large proportions of water, but, in proportion to the dryness of food, water should be added to it, in the form of some kind of beverage.

Quantities of Water in 100 Pounds of different kinds of Solid Food.

Vegetable Food.

Potatoes	lbs. 75	Indian Meal	lbs. 14
Carrots	86	Rye	13
Turnips	87	Peas	14
Parsnips	79	Rice	13
Mangel Wurzel	85	Beans	14
Cabbage	92	Bread	44
Flour	14	Cocoa	5
Barley Meal	14	Lentils	14
Oatmeal	13	Buckwheat	14

Animal Food.

Milk	lbs. 86	Mutton	lbs. 44
Bacon	30	Pork	38
Veal	62	Fish	78
Beef	50	Eggs	80
Lamb	50	Cheese	40

Water for dietetical purposes is obtained principally from three sources :—1. Rivers; 2. Surface wells; 3. Deep or Artesian wells. Water from all three sources contains saline or mineral matters in solution, and, provided they are not in quantities so large as to act injuriously on the system, water may become a source of supply of these constituents to the body. The following Table gives the quantities of saline matters found in waters supplied to the metropolis.

ANALYSIS of the QUANTITIES of SALINE SUBSTANCES found in LONDON WATER.

—	River Thames at Twickenham.	Surface Well at Clapham.	Artesian Well, Trafalgar Square.
Silica - - -	0·27	0·24	0·97
Sulphate of Potash - - -	0·66	6·74	13·67
Sulphate of Soda - - -	2·00	10·77	8·74
Chloride of Sodium - -	—	11·46	20·05
Chloride of Calcium - - -	1·75	—	—
Carbonate of Lime - -	12·75	15·09	3·25
Carbonate of Magnesia - -	1·02	13·97	2·25
Sulphate of Lime - -	0·45	15·32	—
Carbonate of Soda - -	—	—	18·04
Phosphate of Lime - -	—	—	0·03
Phosphate of Soda - - -	—	—	0·29
Total -	18·90	73·59	67·29

Besides these *inorganic* substances, water contains *organic* matters arising from the decomposition of animal and vegetable substances, either growing in the water or cast into it. This organic matter, when it putrifies, may render the water in which it is present very injurious, and even fatal, in its effects. The following analyses give the quantities of organic matter, in grains, in a gallon of surface well, river, and Artesian well waters :—

Surface Wells.

	Organic Matter.	Inorganic Matter.	Total.	Analyst.
Belgrave Mews -	15	110	125	Aldis.
Grafton Street -	26	115	141	Hillier.
Wandsworth Road -	19	72	91	Odling.
Spencer's Court -	14	172	186	R.D.Thomson.
Broad Street (Golden Square) - -	5	102	107	Powell.
River Water.				
Grand Junction Water Company -	$1\frac{1}{2}$	$21\frac{1}{2}$	23	Hoffman.
New River -	1	21	22	,,
Thames at Twickenham - -	2	20	22	Clark.
Deep Wells in Chalk.				
Trafalgar Square -	—	68·	68	Abel.
Richmond - -	·80	27·20	28	Henry.
Long Acre - -	—	57·	57	Graham.

From these analyses it will be seen that the organic matter is most abundant in surface well waters, which derive this matter from soaking through the soil which is permeated with house drainage, &c. The best remedy for impure water is filtering, which may be done by passing the water through charcoal and sand. "A Poor Man's Filter" is exhibited in the Museum, which can be constructed by using a common flower-pot, with a layer of charcoal and sand. Filters from the establishments of the Messrs. Lipscombe, the Messrs. Ransome, and the Carbon Filter Company are also exhibited. The passing water over iron has been found to have a remarkably purifying effect, and this been patented by Dr. Medlock. Specimens of water thus purified are exhibited.

Specimens of Thames water, taken at various points from Southend to Thames Ditton, are exhibited, to show the influence of the sewage of London in rendering the water unfit for drinking purposes.

A series of specimens of waters from the surface wells of the parish of St. James, Westminster, are also exhibited, which show the large quantities of organic matter contained in these comparatively pure surface wells. The erection of drinking fountains supplied with filtered river water will be a great improvement on this kind of water.

Water from the chalk is generally hard, arising from its holding in solution carbonate of lime, which, although insoluble in water, is dissolved by the agency of carbonic acid. By Clark's softening process the carbonic acid is neutralized by lime, and the carbonate of lime is thus thrown down.

Illustrations of this process, presented by Mr. Homersham, are exhibited in the Museum.

The *organic* impurities of water are best tested by the aid of the microscope, but, as an examination by this instrument requires much time, a ready method of obtaining a knowledge of the comparative organic impurity of waters is the addition of the permanganate of soda or potash. This salt, which gives to water a beautiful red colour, is easily decomposed by organic matters. When the same quantity of the permanganate is added to a series of waters containing organic matters, those which contain the least retain the most colour and *vice versâ*. Waters thus coloured are exhibited in the Museum.

SALT.

Common Salt is a chloride of sodium, and exerts an extraordinary influence on animal as well as vegetable life. All marine animals and plants seem to have their existence determined by this substance. It enters into the composition of the human body, and all over the world man uses it, when he can obtain it, in its mineral form, as an addition to his food.

Salt occurs in large quantities in the bowels of the earth, and in many parts of Great Britain and the continent of Europe it is worked for the purpose of supplying the market. It is obtained in the form of Rock Salt, and in Brine Springs, both of which contain many impurities; but, when prepared, it is sold under the names of "bay salt" and "fine salt."

Specimens of this substance from various parts of the world will be found in the Museum.

Salt has the power of preventing the decomposition of animal and vegetable substances. It is extensively employed in this country, sometimes in conjunction with saltpetre (nitrate of potash) for the preservation of pork and beef. In other countries it is employed for the preservation of fruits and vegetables, and might certainly be made more extensive use of in this country than it is for the preservation of the latter for winter use.

MINERAL MATTERS IN FOOD.

Case 2 contains examples of some of the mineral substances known to exist in vegetable and animal food.

This Case is accompanied with the following Labels:—

Mineral Matter in Food.

The body of a man weighing 154 lbs. contains about 8 lbs. of mineral matter, consisting of Phosphoric Acid, Silica (or Flint), Chlorine combined with Sodium (common Salt), Fluorine combined with Calcium (Fluor Spar), Sulphur, Soda, Potash, Lime, Magnesia, and Oxide of Iron. These substances are extracted from food, and distributed by means of the blood to the various parts of the body, where they are taken up, or absorbed, into the system; different portions of the body showing a strong affinity for different mineral substances: thus, Phosphorus is found in the brain, and also in the form of Phosphoric acid in combination with Lime, in the bones; Fluorine in the bones and teeth; Silica or Flint in the teeth, hair, and nails; Sulphur in the hair; Phosphate of Magnesia and Phosphate of Potash in the flesh; and Phosphate of Soda in the blood and the cartilages. In some cases, as in Phosphate of Lime, which forms the ground-work of bones, the use of Mineral matter in the body is sufficiently obvious; but, in other cases, its use is less understood, though it is supposed to exert important action on the transformation of tissues, and the support of respiration. Mineral matter is quite indispensable to health, and disease results from a deficient supply of it. All animals, man included, require salt for the digestive processes and for the proper secretion of bile; in fact, each substance has its peculiar uses, of many of which we are yet to a great extent ignorant.

Minerals in Food.

This Case shows the principal Mineral Substances, excepting water, in food. They are generally essential to proper nutrition. In the body of a man, weighing 154 lbs., there are about 8 lbs. of mineral matter. Different parts of the body show peculiar affection for particular ingredients to the exclusion of others.

1. *Phosphate of Lime*, or Bone Earth, consists of 3 proportions of Lime and 1 of Phosphoric Acid. There is no animal tissue in the body in which it is not present. In bone it forms from 48 to 59 parts in 100; the bones most exposed to mechanical influences containing the largest quantity. It is always found with flesh-forming substances, whether derived from the Vegetable or Animal Kingdoms; generally in the proportion of 0.5 to 2 per cent. Casein contains 6 per cent.

2. *Carbonate of Lime*, or Chalk, always occurs in the bones, though in much less quantity than Bone Earth, the proportions being 1 to 4 parts in a newly-born child, 1 to 6 parts in an adult, and 1 to 8 parts in the old. It is also found in animal concretions.

3. *Phosphate of Magnesia*. This substance is present, in only small quantities, in the bones and in animal fluids.

4. *Fluoride of Calcium*, or Fluor Spar, exists in small quantities in animal tissues, but more abundantly in the bones and teeth.

5. *Silica*, or Flint, exists in small quantities in the enamel of the teeth and hair.

6. *Chloride of Sodium*, or Common Salt, forms the greatest part of the soluble mineral ingredients in all animal tissues. In blood, 6 parts in 1,000 consist of Salt. It no doubt exerts an influence on the change of tissues, on the action of the gastric juice, and on other functions.

7. *Carbonate of Soda* is found in small quantities in blood, and is useful in dissolving Fibrin, Casein, and other flesh formers; it may also aid in respiration.

8. *Phosphates of Soda and Potash*. Salts of Soda and Potash certainly exist both in blood and the tissues, and they may be present as phosphates, but our knowledge on this subject is deficient.

9. *Iron* is found in blood, gastric juice, hair, black colouring matter of the eye, etc.

10. *Sulphates of Soda and Potash* exist occasionally in animal fluids, but do not appear to be essential.

11. *Carbonate of Magnesia* occurs very sparingly in the body, and is not deemed essential.

12. *Oxide of Manganese* is found in bile, gall-stones, etc., but would appear to be only accidentally present.

13. *Copper and Lead* are rarely found in the blood, but generally in the bile, of man. They are no doubt deleterious, and introduced accidentally.

14. *Sulphocyanide of Sodium,* though not existing in food, is found generally in the saliva of man.

It should be recollected, that in the boiling of food many of the mineral substances are dissolved out of it, and where the liquid that they are boiled in is not consumed such mineral matters are thrown away. This is the case with boiled meat and vegetables, and a constant use of such food may lead to injurious effects. The best corrective to such a diet is the use of uncooked fruit and vegetables. In this way the eating of ripe fruits, as apples, pears, gooseberries, &c., and salads, has a beneficial effect on the system.

GROUP II. CARBONACEOUS, RESPIRATORY, OR HEAT-GIVING FOOD.

The substances belonging to this group of food contain three elements, carbon, hydrogen, and oxygen. Carbon is the preponderating ingredient, hence they are called carbonaceous. When taken into the system they do not, with the exception of fat, remain there, but are employed in the production of animal heat, hence they are called *heat-givers.*

The production of heat is effected by the union of the carbon of the food with the oxygen of the air; and the result is the formation of carbonic acid gas. This gas is formed in the same way by the combustion of carbon in the burning of coal, gas, and other substances. The oxygen is introduced into the blood, and the carbonic acid is expelled from it by the agency of the function of respiration; hence these substances are called *respiratory.*

The accompanying Label is intended as an introduction to this class of foods:

Heat-givers in Food.

A class of ingredients in food, such as Starch, Gum, Sugar, and Fat, containing three elements—*Carbon, Oxygen*, and *Hydrogen*, the fourth element, *Nitrogen*, being absent. They are of no use in building up the structure of the body, or in repairing its waste; they are in fact the Fuel which keeps up animal heat. The body of a man has a temperature of 98° Fahrenheit. This warmth results from the burning of these substances, which produce as much heat in the body as they would if burned in an open fire out of the body. A man inhales about 3,000 gallons of air in 24 hours, in order to burn the daily amount of food-fuel, containing about 10 oz. of Carbon or Charcoal. The products of combustion pass out by the mouth, just as they would fly up the chimney of an open fire, were the charcoal burned in it. Less food-fuel is required in hot weather than in cold; and less in hot climates than in cold ones. Tropical foods contain about 20 to 30 parts in the 100 of charcoal; Arctic blubber and fats from 80 to 90. The intense cold of the polar regions compels the inhabitants to devour large quantities of food-fuel to keep up the heat of the body to 98°. Arctic travellers state that 20 lbs. of blubber is not an uncommon meal for one person.

Case No. 3 contains specimens of various kinds of Heat-givers, of which a summary is given in the following Label:

Heat-givers.

The heat of Animals is chiefly supported by the burning, within the body, of substances free from Nitrogen, such as Starch, Sugar, Gum, and Fat; although occasionally Flesh-formers, as in the case of Carnivora, also produce heat. The value of Heat-givers depends upon their relative richness in Carbon and free Hydrogen. To keep the body at the same heat, there must be burned in it the quantities given of either of the following substances:—

Fat	- -	40 parts.
Alcohol	- -	54 ,,
Starch	- -	97 ,,
Cane Sugar	-	100 ,,
Grape Sugar	-	106 ,,
Flesh	- -	310 ,,

These numbers show the relative value of the Heat-givers; Fat being the most, and Flesh the least, valuable.

The Case shows the varieties of Heat-givers found in food.

1. *Cane Sugar* found largely in the Cane, but also in Beet-root, Carrots, Turnips, Potatoes, &c.

2. *Fruit Sugar* is an uncrystallizable sugar found in fruits, and abundantly in Molasses; it is less sweet than Cane Sugar.

3. *Grape Sugar* is the Sugar found in dried Figs, Raisins, &c. It crystallizes; but is much less sweet than Cane Sugar, of which 1 lb. equals 2½ lbs. of Grape Sugar.

4. *Milk Sugar* is a crystallizable sugar found chiefly in the milk of Vegetable feeders, but also in the milk of Carnivora. It is even less sweet than Grape Sugar.

5. *Starch*, as obtained from the Potato and other vegetables. The granules differ in size in various kinds of food, but the chemical composition is not different except in the case of the Dahlia, Chicory, &c., which contain *Inulin*, a peculiar variety of Starch.

6. *Gum* is found in the juices of almost all plants. In Gum Arabic it is nearly pure. Linseed, Quince-seed, &c., contain a modification of gum called Mucilage, or *Bassorin*, which softens but does not dissolve in water.

7. *Pectin*, found in Turnips, Carrots, Parsnips, Pears, Apples, &c., is a kind of gummy or gelatinous substance, and is similar to other substances known as vegetable jelly, pectic acid, &c.

8. *Cellulose, or Woody Fibre*, forms the ground-work of all plants, and is the same in composition though variable in texture. Cotton and Linen are nearly pure Cellulose.

9. *Fat*, being rich in Carbon, is a powerful heat-giver, though it is doubtful whether it is so easily combustible in the body as Starch or Sugar. It plays an important part in the animal economy, and is found in all food. Fats of a like kind exist both in Animals and Vegetables.

Alcohol was formerly regarded as a Heat-giver, but recent experiments lead to the conclusion that it contributes to this process only by exciting the circulation. Its properties will be mentioned under Auxiliary Foods. Of the series in the Case, Gum, Pectin, and Cellulose do not appear to aid much, if any, in the function of producing animal heat.

STARCH.

Various preparations of Starch are exhibited in the Cases 4, 5, and 6. They are generally described in the accompanying Label.

Starch.

(*Amylum.*)

The substance called Starch is found very abundantly in the vegetable kingdom. Its presence was at one time regarded as characteristic of plants, but it has recently been found in the animals. It occurs in the form of irregularly-shaped granules, which vary in size from the $\frac{1}{400}$ to the $\frac{1}{2,000}$th of an inch in diameter. These granules are simple or compound. They vary in shape and size in every species of plant, and are insoluble in water, but are easily diffused through it. They are thus separated from the insoluble Cellulose, amongst which they are deposited in plants. In order to separate the Starch, the plant is bruised or crushed, and put into a vessel of water, when the Cellulose sinks, and the Starch is diffused through the water, which is decanted and set aside till the Starch is deposited. On being mixed with water, and exposed to a temperature of 180°, the Starch gelatinises, and, mixing with the water, thickens it. This occurs in the cooking of Starch, and this property lies at the foundation of pudding making.

Starch is turned blue by Iodine, which is the best test of its presence. It is composed of Carbon, Hydrogen, and Oxygen, of which Carbon constitutes one half by weight, and the Hydrogen and Oxygen are in the proportions to form water. When Starch is taken as an article of diet, the Carbon is burned in the system in contact with the Oxygen of the air, and carbonic acid gas is formed and heat is given out. Starch is readily converted into Glucose or Grape Sugar by the action of nitrogenous substances, especially the salivine of the saliva, and it is in the form of Glucose that it enters the blood of animals. All Starch in diet, not converted into Glucose, is waste. Starch is, therefore, less readily convertible into aliment than Sugar.

Starch is abundantly present in all the more common forms of vegetable diet. It exists in a state of almost absolute purity in the substances known as Arrowroot, Tapioca, and Sago. These substances, from whatever source obtained, contain little or no nutritious or flesh-forming food, and, consequently, ought never to become the substantive diet of human beings. Many plants contain so large quantities of Starch, and so small quantities of flesh-forming matter, that they ought only to be taken on account of their Starch. Such are the Potato and Rice, in which the quantity of Starch to flesh-forming matter is as 14 to 1, whilst in wheat it is only as 5 to 1. Potatoes and Rice, therefore, can never form the staple article of the diet of the people of this country, who

need a large quantity of flesh-forming matter in order to enable them to perform their work.

During the growth of plants, Starch is converted into Dextrine, Gum, and Sugar; it also assumes different properties in certain groups of plants. Thus it exists in an amorphous form in Sea Weeds and Lichens, and is then called Lichenine; and there are other varieties, as Friuline found in the Elecampane.

Starch is extensively used in the arts. It is prepared for this purpose from the potato, wheat, rice flour, and the coarser kinds of Sago.

Common Starch, which is used for domestic and manufacturing purposes, is obtained from Wheat, Rice, Potatoes, and other sources. Sago is a form of Starch obtained from several kinds of plants. That which is most commonly used in Europe is the produce of the Sago Palm (*Sagus lævis*), which grows in the islands of the Indian Archipelago. The Sago is obtained from the cellular tissue in the interior of the trunk of the tree. Other palms, as the *Sagus Rumphii* and the *Saguerus saccharifera*, also yield Sago. A coarse kind of Sago is also obtained in the East Indies from various species of plants belonging to the order *Cycadaceæ*. Such are *Cycas circinalis*, *Dion edule*, and *Encephalartos horrida*.

Arrowroot is also a name given to various forms of Starch, obtained more especially from the root-stocks of plants. The most common source of Arrowroot is the *Maranta arundinacea*, which is a native of tropical America and the West Indian islands. This plant yields the best West Indian and Bermuda Arrowroots. Another species, the *Maranta Indica*, is said to yield the East Indian Arrowroot. The *Tous les Mois* is produced by a plant belonging to the same order, the *Canna edulis*, which is a native of Peru. Arrowroot is prepared from the root of the water-lily in China.

Tapioca is Starch from the Mandioc Plant, *Janipha Manihot* (*Jatropha Manihot*). This plant is a native of South America, and belongs to the order *Euphorbiaceæ*. It contains hydrocyanic acid, and is very poisonous. The

poison is, however, separated from the root, and, after preparation, it yields Cassava and Tapioca. Cassava is formed into cakes and eaten by the natives. Tapioca is extensively consumed in Europe for the same purposes as Sago and Arrowroot.

Cakes and various other preparations are made from Arrowroot, Sago, and Tapioca.

Salep or *Saloop* (Case No. 14A) consists principally of Starch, and is prepared from the roots of the common male Orchis (*Orchis mascula*). When it is boiled it forms an agreeable article of diet, and was commonly used in this country before the introduction of tea and coffee. Sassafras chips were frequently introduced into the decoction for the purpose of giving it a flavour. The roots of the *Orchis maculata* also yield an inferior kind of Salep. Although now almost entirely disused in this country, it is still used in Turkey and the East.

Starch differs in its physical and chemical properties according to the plants from which it is obtained. Thus *Inuline* is a form of Starch obtained from the Elecampane (*Inula Helenium*), a plant not uncommon in this country.

Lichen Starch or (*Lichenine*) is found in Lichens and in Algæ. This Starch has the same power of thickening water at a high temperature as Arrowroot, Sago, and Tapioca. The gelatinous character of the liquid thus obtained has led to the erroneous supposition that it is nutritious, and to the use of Lichens and Sea-weeds as articles of diet.

One of the plants of this kind, which has been used most extensively, and is still largely employed, is the Iceland Moss (*Cetraria Islandica*). It belongs to the family of Lichens, and is a native of the northern parts of the world. This and other Lichens probably contain other dietetical secretions besides Starch, as we find they are capable of supporting animal life. The Rein-Deer Moss (*Cenomyce rangiferina*) is an instance of this. In the northern parts of the world, as well as in mountainous districts, this Lichen grows in great abundance, and during the winter season is the principal support of the rein-deer. In spite of the extreme cold to which it is subjected, this plant

grows with vigour, and the rein-deer, in order to obtain it as food, is obliged to remove with its nose the snow with which it is sometimes covered for many feet. The Cup Moss (*Cenomyce pyxidata*) of our own moors belongs to the same genus as the Rein-Deer Moss, and is also used as an article of diet in the same way as the Iceland Moss. The *Tripe de Roche* is another of these Lichens which has been used as an article of diet. It has a melancholy interest attached to it, as it has so often formed the chief article of diet of our arctic navigators. Two species of Lichens, the *Gyrophora proboscidea* and *G. erosa* afford the *Tripe de Roche.* Although they are said to be nutritious, they are described as having bitter, nauseous, and purgative properties.

Amongst the sea-weeds (*Algæ*) (Case 7) which have been used as articles of diet, none is better known than the *Chondrus crispus*, which, under the name of Carrageen Moss, Irish Moss, and Pearl Moss, has been for a long time used in Europe. It grows on the rocky sea-shores of Europe; and when washed and dried, and then boiled with water, makes a mucilaginous decoction, which, like the same preparation of the Iceland Moss, has been recommended in consumption, coughs, diarrhœa, and other diseases. It has, however, no bitter principle, and is probably less tonic than the Lichen. This and other sea-weeds have been occasionally had recourse to by the poor inhabitants of the sea-shores of Europe, more especially Ireland, when the ordinary corn or potato crop has failed. They contain, however, but little nutritious matter, and persons soon famish who live upon nothing else. There are certain forms of sea-weed which are often eaten as an addition to other kinds of food. There is in all of them a certain flavour of the sea, arising, probably, from the saline matter they contain, which renders them very objectionable to some persons as articles of food, and which will, probably, always form an objection to their general use. Of those which are eaten in England, we may mention—

1. Laver, Sloke, Slokam (*Porphyra laciniata*). It is found on all our sea-shores, and when employed as food is salted and eaten with pepper, vinegar, and oil.

2. Green Laver, Green Sloke, Oyster Green (*Ulva latissima*). The Ulva is not so good to eat as the Porphyra, and is only had recourse to when the latter is not abundant.

3. Tangle, Sea Ware, Sea Girdles, Sea Wand, Red Ware (*Laminaria digitata*). It is cooked by boiling for a long time, and adding pepper, butter, and lemon juice. Cattle are fed on it in some parts of the British islands.

4. Badderlochs, Hew Ware, Honey Ware, Murlins (*Alaria esculenta*). The part of the plant which is eaten is the thick middle rib which runs through the frond. It is sometimes called the Eatable Fucus.

5. The Dulse of the south-west of England is the *Iridea edulis* of botanists. It is eaten by the fishermen of the south-west coasts of England, who before eating it pinch it between red-hot irons. In Scotland it is cooked in the frying-pan. It is said to resemble in its flavour roasted oysters.

6. Dulse of the Scotch, Dellisk, Dellish, Duileisg, Water-Leaf (*Rhodomenia palmata*). The Islanders and Irish, before the introduction of tobacco, were in the habit of drying this weed and using it as a masticatory. The Icelanders use it as an article of diet, under the name of the Sugar Fucus. In the islands of the Mediterranean Archipelago it is employed as an ingredient to flavour soups, ragouts, and other dishes.

Several other sea-weeds have been employed as food, but these are the principal that are at present used in this country. In China the people are very fond of sea-weeds, and many kinds are collected and added to soups, or are eaten alone with sauce. One of these, the *Plocaria tenax*, is sometimes brought to this country under the name of Chinese Moss. The decoction it makes is so thick that it is used as glue. The Corsican Moss, which has a reputation in medicine as well as a diet, is the *Plocaria Helminthocorton*, and is found on the coasts of the Mediterranean. Another sea-weed was recently imported into London under the name of Australian Moss (*Eucheuma speciosum*); but,

although affording a very thick jelly, it tastes too strongly of the sea to be rendered pleasant by any kind of cooking. Another sea-weed used at Valparaiso is the *Durvillea utilis.* Specimens of the two latter have been presented to the Museum by Dr. Harvey, of Dublin.

Many kinds of food contain so much Starch, in proportion to the flesh-forming or nutritive matters, that they ought more properly to be classed with carbonaceous than with nitrogenous foods. On this account the Potato and Rice have been placed with the starch-yielding foods (Cases 8, 9, 10, 11, 12).

THE POTATO.

Although this plant contains but a small quantity of flesh-forming matter, it yields an abundance of Starch and mineral matters in a condition which acts very beneficially on the human system, and its introduction into Europe has been of the greatest benefit to its teeming populations.

The following Labels are descriptive of its history and composition :—

Potato.

(*Solanum tuberosum.*) Nat. Ord. Solanaceæ.

The Potato is an herbaceous plant producing annual stems from an underground tuber or root-stock which is the part that is used as an article of food. It has white flowers and a green fruit, which, like all the plants of the order to which it belongs, contain a poisonous principle. The native country of the plant is South America. It has been found wild in various parts of Chili, and also near Monte Video, Lima, Quito, Santa Fe de Bogota, and in Mexico. This plant was first cultivated in Spain in Europe, from thence it extended into Italy. It was first grown in the British Islands by Sir Walter Raleigh in his garden at Youghal in Ireland, but it was not generally cultivated in Great Britain till the middle of the last century. The only part of the plant employed as food is the tuber which is a kind of underground stem. Upon this stem buds are formed which are called "eyes," and from these, by cutting up the potato, the plant is propagated. The tubers of the wild potato are small in size, but by culture they may be very much enlarged. In this country many varieties of the potato are known under the name of "kidneys," "rounds," "reds," "blues," "whites," &c. Many of these varieties are now disappear-

ing, the "white," "kidney," and "round" potatoes being preferred to all others. The potato contains large quantities of water (75 per cent.), and less flesh-forming to the heat-giving matters than any other plant cultivated for human food. It is therefore not adapted for consumption as a principal article of diet, and should only be employed as an addition to more nutritious kinds of food. It contains a variety of mineral matters which also render it valuable as an article of diet. It has for many years been liable, in Europe, to a diseased condition in which the water seems to be increased, and decomposition consequently readily sets in. The decayed parts are attended with a Fungus, but this has really nothing to do with the production of the disease. Potatoes are largely employed in this country for the production of starch, which is used for a variety of purposes in the Arts. Potatoes are cooked in many ways, and all the varieties of food which can be obtained from the flour of the Cerealia may be procured from the potato, as starch, maccaroni, vermicelli, &c. The quantities of potatoes consumed in the United Kingdom is about ten millions of tons annually.

Potato.

(*Solanum tuberosum.*)

The Potato, from its poverty in flesh-formers, is little nutritive: 100 lbs. of fresh potatoes contain only $1\frac{1}{2}$ lb. of flesh-forming matter. In 100 parts there are:—

Water	75·2.	or,	Water	75·2.
Flesh-formers	1·4.		Flesh-formers	1·4.
Starch	15·5.		Heat-givers	22·5.*
Dextrin	0·4.		Mineral matter	0·9.
Sugar	3·2.			
Fat	0·2.			
Fibre	3·2.			
Ashes	0·9.			

The Case shows the actual quantities of these ingredients in 1 lb. of fresh potatoes:—

1. 1 lb. of fresh potatoes containing 75 per cent. of Water.

2. 1 lb. of potatoes after the Water has been evaporated —4 oz.

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* In this and the following Tables the Heat-givers include Gum, Pectin, and Cellulose or woody fibre, which, as they are generally indigestible, probably do not act upon the system. They are generally, however, in small quantities.

3. The quantity of Water got from 1 lb. of potatoes—12 oz.

4. The quantity of flesh-formers found in 1 lb. of potatoes—$\frac{1}{3}$ oz.

5. The quantity of Starch in 1 lb. of potatoes—$2\frac{1}{2}$ oz.

6. The quantity of Sugar found in 1 lb. of potatoes—$\frac{1}{2}$ oz.

7. The quantity of Dextrin, or Gum, found in 1lb. of potatocs—$\frac{1}{10}$ oz.

8. The quantity of Fat found in 1 lb. of potatoes—$\frac{7}{100}$ oz.

9. The quantity of Woody fibre found in 1 lb. of potatoes—$\frac{3}{4}$ oz.

10. The quantity of Mineral matter, or Ashes, in 1 l. ofb potatoes—$\frac{7}{8}$ oz.

11. *The quantity of Carbon found in* 1 *lb. of the foregoing substances—2 oz.*

RICE.

(*Oryza sativa.*)

This plant belongs to the natural order of Grasses (*Graminaceæ*). It is a native of the East Indies, and, unlike many of the cultivated cereals, is found wild about the borders of lakes in the Rajahmendy Circars. The wild plant does not yield so much as the cultivated varieties. Rice is now cultivated extensively in Asia, from whence it has extended to the southern parts of Europe, and been introduced into America. It is extensively cultivated in the marshy grounds of North and South Carolina. It is brought into this country from various parts of the world, and, in 1852, 35,000 quarters were imported. A large number of varieties are known in the countries where it is cultivated, and specimens are exhibited in Cases 12 and 13. The most abundant varieties are known under the names of "common rice," "early rice," "mountain rice," and "clammy rice." Rice in the husk is known by the name of "Paddy." Although Rice is more largely consumed by the inhabitants of the world than any other grain, it contains less flesh-forming matter. This will be seen by the following analysis:—

(*Oryza sativa.*)

Rice, though used largely as an article of food, is poor in flesh-formers, which scarcely amount to 7 parts in 100; and

from its small quantity of fat it is not a laxative food. In heat-givers it is rich. One hundred parts of Rice contain the following ingredients:—

Water	13·5.	or,	WATER	13·5.
Gluten	6·5.		FLESH-FORMERS	6·5.
Starch	74·1.		HEAT-GIVERS	79·5. { CARBON 38·0.
Sugar	0·4.		MINERAL MATTER	0·5.
Gum	1·0.			
Fat	0·7.			
Fibre	3·3.			
Mineral matter	0·5.			

The Case shows the ingredients in 1 lb. of Rice.

1. Shows 1 lb. of Rice with its husk.
2. 1 lb. of Rice deprived of its husk.
3. Water from 1 lb. of rice— $2\frac{1}{8}$ oz.
4. Gluten in 1 lb. of rice—1 oz.
5. Starch in 1 lb. of rice—$11\frac{8}{10}$ oz.
6. Sugar in 1 lb of rice—$\frac{1}{16}$ oz.
7. Gum in 1 lb. of rice—$\frac{1}{5}$ oz.
8. Fat or Oil in 1 lb. of rice—$\frac{1}{8}$ oz.
9. Woody fibre in 1 lb. of rice—$\frac{1}{2}$ oz.
10. Ashes in 1 lb. of rice—$\frac{1}{16}$ oz.
11. *Carbon in* 1 *lb. of the above substances*—6 *oz.*

Rice can only be the substantive article of diet of an indolent and feeble people. When employed in this country it should only be used as an adjunct to other kinds of food more rich in flesh-givers. Boiled, as an addition to meat, or in the form of pudding or curry, it may be judiciously employed, as a variety, especially in the food of the young.

The following Table gives the quantities of Starch in 100 parts of various kinds of food:—

Rice	74	Rye	51
Potatoes	15	Lentils	35
Oats	39	Carrots	11
Wheat	59	Turnips	10
Beans	36	Parsnips	17
Barley	48	Mangel Wurzel	12
Peas	37	Cabbage	4
Buckwheat	50	Bread	48
Maize	60		

SUGAR.

Sugar has a chemical composition very nearly resembling starch, but it differs in both chemical and physical properties. Sugar is soluble in water, whilst starch is only diffusible through it. Sugar undergoes the process of fermentation, which starch does not. Sugar has a sweet taste, whilst starch is almost tasteless. Starch is, however, convertible into sugar by the agency of nitrogenous substances. If starch is placed in contact with saliva a little time, it becomes soluble, and gives the reactions of sugar; and it is probable that in this way starch itself becomes absorbed into the blood. Sugar, like starch, assumes various forms, and three of these are found in common articles of diet. These are—

Cane sugar (*Sucrose*),
Grape sugar (*Glucose*), and
Milk sugar (*Lactose*).

They vary in composition as follows:—

	Carbon.	Hydrogen.	Oxygen.
Cane sugar - - -	12	10	10
Grape sugar - -	12	12	12
Milk sugar - -	11	12	12

They are all sweet and soluble, but the two latter differ from the first in the readiness with which they enter into a state of fermentation and become decomposed. Although cane sugar ferments, it must be first converted into grape sugar.

The action of sugar on the system is identical with starch. As it is more readily absorbed into the blood than starch, it is better adapted as a heat-giver for the young. Hence it is found supplied to the young in all the mammalia, in the milk secreted by their mothers. That it is adapted for the young is shown by the instinctive propensity children display to partake of this form of diet. Although adapted for children, the facility with which it decomposes renders it frequently injurious to adults.

Cane sugar is found very generally in plants at certain periods of their growth. Thus it is found during germination in the seeds. This is well illustrated in the process

of malting, which consists in allowing the seed of the barley to germinate; and when the starch has been converted into sugar, the process of growth is arrested, and sugar secured for the purposes of fermentation. All kinds of grain may be thus converted into malt, and used for the purposes of making wine, beer, and distilled spirits.

Another period at which plants contain sugar is previous to the unfolding of their buds. Thus in the spring of the year the sap of the birch (*Betula alba*) contains sugar, and in Scotland it is collected and fermented, and birch wine is manufactured. Large quantities of sugar are annually obtained in America from the sap of the sugar maple (*Acer saccharinum*). Many other trees yield sugar in their sap.

The grasses and the palms contain the largest quantity of sugar in their sap when their leaves are perfected, and they are about to blossom. This is the case with the sugar-cane (*Saccharum officinarum*), the plant from which the chief supplies of sugar are obtained which are consumed in this country. The jaggary palm (*Caryota urens*), the cocoa-nut palm (*Cocos nucifera*), the wine palm (*Saguerus saccharina*), and many others, yield sugar in their sap, which is extensively employed by the natives of tropical climates as an article of diet, and for the production of wine. Sugar is obtained in the United States of America from the stalks of the maize, by cutting the plant down previous to its period of flowering.

All the ordinary grasses contain sugar, and those which are found best for feeding cattle contain the largest quantities. A grass has lately been introduced into this country from the north of China, of which the following is a brief account:—

The Chinese Sugar Millet, or Sugar Sorgho.

(*Sorghum saccharatum. Holcus saccharatus.*)

This plant, like the sugar-cane, belongs to the family of grasses, and is cultivated in the north of China for the sugar it contains. It has been grown successfully in France, Lombardy, Tuscany, Russia, Algeria, the United States, and Australia. The specimens exhibited were grown in the

neighbourhood of London, and other parts of this country, and contain a considerable quantity of sugar. Sugar has been obtained from the plant in France; and syrup, rum, wine, cider, and vinegar have been made from it. It is highly recommended as a fodder for cattle, the produce being variously estimated at from 20 to 50 tons per acre. A variety of this millet, or an allied species, is cultivated by the Zulu Kafirs under the name of *Imphee*, which likewise yields sugar, and the seeds of which are eaten by the Kafirs. Poultry and other animals may be fed on the seed of the sugar millet. The sugar is said to be most abundant after the seed is ripened, and it remains in the plant long after it is gathered, and may be extracted from the cane when it is quite dry. In France, starch and semola have been prepared from the seeds.

Most plants contain sugar in their roots. But in some, large quantities are deposited, as in the Beet, or Mangel Wurzel (*Beta vulgaris*), which is employed most extensively in France and on the continent of Europe for the supply of sugar for dietetical purposes. A series of specimens illustrating the manufacture of Beet-root Sugar, from Messieurs Serret, Hamoir, and Co., of Valenciennes, are exhibited in the Museum.

In all cases the preparation of the sugar depends on the same principles. The juice of the plant containing the sugar in solution is submitted to a process of purifying and evaporation, and the sugar is allowed to crystallize. This sugar, as it is obtained from the sugar-cane in the West Indies, is called "Brown Sugar" (Case 15). Sugars brought in this state from our own colonies are called "Muscovado Sugars," whilst those brought from foreign colonies are called "Clayed Sugars." The difference consists mainly in the fact that the latter are drained by applying damp clay at the top of the hogshead.

The brown sugar is refined in this country. Formerly, this process was effected by boiling the sugar with bullocks' blood and other albuminous substances. Now, lime is more frequently used, and a process has been recently patented in which burnt alumina is employed. Specimens of this process are exhibited by Messrs. Oxland, of Plymouth, in Case 16.

Sugar is the basis of all kinds of confectionery, of which a variety of specimens are exhibited by Messrs. Fortnum and Mason, Piccadilly, in Case 18.

When refined sugar is melted and pulled out whilst cooling, it constitutes "Barley Sugar." When brown sugar is melted and butter added, "Toffy" is formed. When the sugar is melted, and it is allowed to cool and crystallize gradually, "Sugar Candy" is formed. This is brown or clear according to the sugar employed, and is coloured with various colouring matters. When the sugar is melted and various seeds, flavours, and colours introduced, it is called by various names, as "Comfits," "Bon-bons," &c. Care should be taken that mineral matters are not introduced to colour these articles of taste, as fatal consequences have frequently resulted from eating confectionery coloured with poisonous substances.

In Case 17 a variety of sugars are exhibited, obtained from different kinds of plants. They are as follow:—Bengal Date Sugar; Cocoa-nut Sugar; Sugar from Egypt, the Sandwich Islands, and Natal; Beet-root Sugar; Maple Sugar; and Sugar of Milk.

When organic substances are mixed with sugar they can be kept for a great length of time without decomposition. From a knowledge of this fact has arisen the practice of making "jellies," "jams," and "preserves" of fruits in sugar. Apples, pears, apricots, cherries, damsons, plums, gooseberries, currants, and other fruits are thus preserved. A collection of these are exhibited by Messrs. Batty and Son, of London.

Fruits after being saturated with sugar are also preserved and kept dry. A Case of preserved fruits of various kinds are exhibited by Messrs. Fortnum and Mason. It is in this way that fruits are brought to this country which otherwise would not be seen on account of their perishing nature.

In the collection of Chinese foods there will be found a number of curious fruits and substances which could only be preserved by the aid of sugar.

Cane Sugar, when exposed to a high temperature, is

charred, and becomes of a black colour. Under the name of "Burnt Sugar," it is used for colouring sherry, brandy, vinegar, and other liquids to which it is thought desirable to communicate a dark colour. When it has undergone the same process, and is solid, it is called "Caramel," and is used for the same purposes.

Treacle or *Molasses* is the uncrystalized portion of sugar which is separated by draining from the brown sugar. It is brought into this country in large quantities, and consumed both in the arts and as an article of diet. Treacle is dark or clear according to the impurities it contains. When clarified it resembles syrup, and as a saccharine food is quite unobjectionable. Lollypops are made from treacle. It is also used in the preparation of the coarser kinds of gingerbread.

Grape Sugar or *Glucose* is found in the fruits of plants, and is especially abundant in the grape. Cane sugar, woody fibre, starch, sugar of milk, are all converted into grape sugar by the action of dilute acids. It may also be obtained from starch by the action of infusion of malt or of diastase. A sugar is also formed in the human system either identical or closely analogous to glucose. This sugar is formed in the liver, and apparently formed from the various materials of the food. It is probably by the agency of this liver sugar that the heat-giving substances are used in the system for the purpose of producing animal heat.

Of the various forms of sugar, glucose appears to be the only fermentable form, and when cane or milk-sugar are fermented they first assume the form of glucose. This form of sugar is most commonly found in fruits, and it is especially abundant in the fruit of the grape; hence it is called grape sugar. Grapes, when dried, are eaten on account of the glucose they contain. They are known in the shops under the name of "plums," "raisins," and "currants." The latter word is a corruption of Corinth, the small grape yielding this, being cultivated in the vicinity of Corinth, on the classic soil of Greece.

Dried fruits of the grape-vine, presented by Messrs. Fortnum and Mason, Piccadilly, are exhibited in Case 21.

Grape sugar or glucose occurs in fruit both in a crystallized and uncrystallized state. The latter can be formed from starch by boiling it with dilute sulphuric acid. It is then called *starch-sugar*. Sometimes the term "glucose" is applied alone to this form of sugar.

Honey, which is the stored food of the bee, contains both crystallizable and uncrystallizable grape sugar. The crystals of the former may be easily detected by the aid of a low power of the microscope.

Standing between starch and sugar are many vegetable substances having a chemical composition closely allied to them, but differing in physical properties. Some of these enter into the composition of food, although it is very doubtful if they act on the system in the same way as starch and sugar.

Dextrine (Case 10) is formed in plants whilst starch is passing into the composition of sugar. Like sugar it is soluble in water, but not sweet.

Gum may be regarded as fixed dextrine; it is soluble in water, but incapable of being converted into sugar. Although gum enters largely into some kinds of food, it does not enter the blood or act as an aliment. It may be therefore properly regarded as an accessory food. Sugar is added to it, and it is used in the manufacture of lozenges. These are flavoured with various substances, as in the case of the *Pâté de Jujubes*. (Case 20.)

Liquorice is found in many plants, but it is separated from the juice of the Liquorice Plant (*Glycyrrhiga glabra*). Like gum it is soluble in water, and has the sweet taste of sugar. It differs from sugar in not being fermentable. It is obtained from the root of the Liquorice Plant in the form of an extract, and comes to this country in solid sticks, which are sold under the name of "Spanish Juice." This is boiled down and refined, and sold under the name of "refined or pipe liquorice." The liquorice plant is cultivated extensively at Pontefract or Pomfret in Yorkshire, and a manufacture of the liquorice is carried on in that town. The liquorice is made into cakes, which are called "Pomfret cakes." Liquorice, like gum, does not act as an aliment in the system. (Case 16A.)

Manna is another sweet substance, soluble in hot water, but not capable of fermentation. It is obtained for medicinal purposes from a species of ash, the *Fraxinus ornus.* Several other plants yield manna, and it is used in some countries as an article of diet. Its value is, however, doubtful. This substance has sometimes been supposed to be the "manna" of Scripture, but the putrescent nature of that substance, and the absence of dietetical properties in the substance in question, renders this supposition exceedingly doubtful.

There are other kinds of so-called sugar, as Mushroom Sugar and Eucalyptus Sugar, but these are not used as articles of diet.

Amongst plants yielding sugar may be enumerated the Sweet Potato, of which the following is an analysis:—

Sweet Potato.

(*Convolvulus Batatas.*)

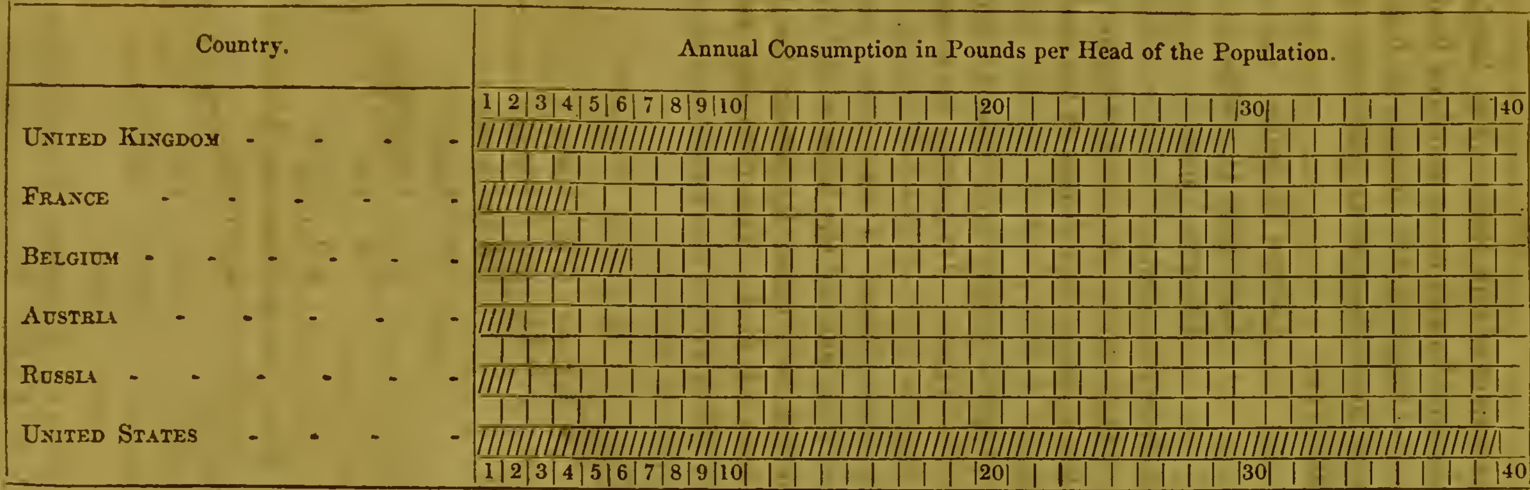
The Sweet Potato is eaten largely in Tropical America. It may be used as food as a substitute for the Potato. In 100 parts it contains:—

Water	67·50.	or,	Water	67·50.
Starch	16·05.		Flesh-formers	1·50.
Sugar	10·20.		Heat-givers	26·55.
Albumen	1·50.		Accessories	1·55.
Fat	0·30.		Ashes	2·90.
Woody Fibre	0·45.			
Gum, &c.	1·10.			
Ashes	2·90.			

The Case shows the quantities of the above ingredients in 1 lb. of Sweet Potatoes.

1. 1 lb. of Sweet Potatoes.
2. 1 lb. of Sweet Potatoes, after the water has been evaporated.
3. Water - - - - 10 oz. 340 gr.
4. Starch - - - - 2 oz. 249 gr.
5. Sugar - - - - 1 oz. 277 gr.
6. Albumen - - - - - 105 gr.
7. Fat - - - - - - 18 gr.
8. Woody Fibre - - - - 35 gr.
9. Gum, &c. - - - - - 77 gr.
10. Ashes - - - - - 210 gr.

TABLE, showing the RELATIVE CONSUMPTION of SUGAR in different COUNTRIES.



Oil.

Under the names of Oil, Butter, Fat, Lard, Suet, Tallow, a substance is used largely as an article of food, which differs from starch and sugar in the absence of oxygen gas. The composition of these oleaginous substances may be represented as follows :—

Carbon 11 parts.
Hydrogen 10 parts.
Oxygen 1 part.

Oil differs from the other carbonaceous substances in food in not only supplying materials for maintaining animal heat, but in forming a part of the tissues of the body called fat.

Its action as a heat-giver is greater than starch and sugar, as it supplies hydrogen as well as carbon for burning in contact with oxygen. Its power as a heat-giver compared with these is as two-and-a-half to one. The quantity consumed in animal food is very large, constituting frequently more than half of the bulk of the food consumed. It is also found very generally present in the vegetable substances used as food. The following table gives the quantities of oil or fat in one hundred pounds of the more common articles of food :—

Vegetable Food.

Potatoes	0·2	Rice	0·7
Wheat Flour	1·2	Beans	2·0
Barley Meal	0·3	Cocoa	50·0
Oatmeal	5·7	Lentils	2·0
Indian Meal	7·7	Buckwheat	1·0
Rye	1·0	Tea	4·0
Peas	2·0	Coffee	12·0

Animal Food.

Milk	3·5	Mutton	40·0
Pork	50·0	Fish	7·0
Veal	16·0	Cheese	25·0
Beef	30·0		

The action of oil on the system is not, however, confined to its heat-giving powers. It seems essential to the development of the fleshy parts of the body. Hence it is found

present in the eggs of animals in that part which becomes the young animal. It is, for instance, present in the yolk of all eggs eaten as articles of food. It is probably on this account that fish oil is found so valuable in those diseases where a wasting of the flesh is present, as in consumption.

The animal system has the power of converting starch and sugar into fat. Thus animals fed on substances containing little or no fatty matter become fat. All ruminant and hybernating animals become fat in the summer and autumn.

The fat thus accumulated is consumed during the winter in maintaining the heat of the body, so that these animals are very thin in the spring of the year. Man to some extent obeys the same law, and weighs heavier during the summer than the winter months.

Although essential as an article of diet in certain quantities, oil is less digestible than other kinds of food, and those foods which contain it in large quantities are generally indigestible.

Oils vary in their chemical composition and physical properties. Some are liquid at all temperatures, whilst others remain solid at the ordinary temperatures of the atmosphere. Many vegetable oils, as cocoa-nut oil and olive oil, contain two principles, one of which is liquid and remains so at all ordinary temperatures; the other is solid when the temperature falls below 40 degrees. The former is called *oleine*, the latter *stearine*. Fats, lards, and butters are composed of the latter, or of principles having the same property.

Oleine, stearine, and other fatty principles, consist of acids combined with a base. This base is called *glycerine*, and is separated from oils in the process of soap-making. The alkali in this case combines with the fatty acids, and the glycerine is set free. (See Oils and Fats in the Animal Museum.)

The principal source of oil used as food from the vegetable kingdom is the olive (*Olea Europea*). This plant is cultivated in the south of Europe. The part of the plant which

contains the oil is the fruit. The berries of the olive are pressed, and yield the oil which is so extensively employed on the continent of Europe under the name of salad oil. In countries where little butter or fat meat is employed as food, this oil is a most important ingredient in diet.

The seeds of most plants contain oil in addition to starch and other principles. Many seeds are used for obtaining oil for various purposes in the arts, as the poppy, rape, mustard, hemp, and flax seeds. The following seeds, eaten as food, contain oil, and are exhibited in Cases 22, 22 A, and 23 :—

Almonds - -	(*Amygdalus communis*).
Chesnuts - -	(*Castanea vesea*).
Walnuts - -	(*Juglans regia*).
Brazil Nuts - -	(*Bertholetia excelsa*).
Spanish and Hazel Nuts	(*Corylus avellana*).
Hickory Nuts -	(*Caryæ spec*).
Beech Nuts - -	(*Fagus sylvatiea*).

The seeds of many other species of plants are eaten under the name of nuts, and the oil they contain is probably their chief recommendation.

The seeds of many of the palms yield large quantities of oil, especially the oil palm (*Elais guineensis*) of Africa. The seed of the cocoa-nut palm is used as a substantive article of diet in Ceylon and many parts of the East Indies (Case 82). It is imported into this country for the sake of the oil it contains. The milk in the interior of the seed is a bland fluid, and, when the nut is fresh-gathered, is a cool and pleasant drink. In the young state the seeds of most palms are filled with a cool fluid consisting mostly of water. This fluid is drunk by the inhabitants of the countries in which they grow. The double cocoa-nut of the Seychelles Islands (*Loidicea Seychellarum*) contains sometimes as much as fourteen pints of water, and is drunk by sailors touching on these islands with great relish (Case 24). Even the hard ivory-nut (*Phytelephas macrocarpa*) contains, when young, a fluid which is drunk by the natives of the countries in which it grows.

Many of the specimens in Case 82, consisting of edible

products of the palm tribe, with the specimens in Cases 22 and 23, have been presented to the Museum by Messrs. Keeling and Hunt, Monument Yard, and Messrs. Fortnum and Mason, Piccadilly.

Amongst vegetable foods yielding oil the cocoa or chocolate plant is one of the most remarkable (Case 24). The seeds of this plant contain 50 per cent. of a hard oil or butter.

Food is sometimes preserved in oil which, on account of the small quantity of oxygen it contains, prevents animal or vegetable substances from putrefying. A familiar instance is known in this country in the case of the fish called sardines, which are thus preserved. Oil is used for this purpose in China, and some specimens will be found in the collection of Chinese food in the jars above Cases 90, 91, and 92.

GROUP III. NITROGENOUS, NUTRITIOUS, OR FLESH-FORMING SUBSTANCES.

In the tissues of all plants a substance is found which was known to chemists under the names of gluten, legumin, diastase, zymone, &c. This substance was called by Mulder *protein*, and shown to be identical with the animal substances called albumen, fibrine, caseine, &c. By this discovery it was demonstrated that the source of the substances forming the flesh of animals is the protein of plants. Whether it occurs in animals or plants, it may be divided for practical purposes into three forms,—albumen, fibrine, and caseine.

Albumen is found in plants, in the juice of cabbages, asparagus, chesnuts, wheat, rye, &c. ; in animals, in the blood nerves, and the white of eggs.

Fibrine is found in plants, in wheat, barley, oats, rye, &c. ; in animals, in their muscular tissue or flesh.

Caseine is found in plants, in peas, beans, lentils, and the seeds of all *Legminosæ* ; in animals, almost exclusively in the milk of the mammalia.

The following label is introductory to these flesh-forming matters :—

FLESH-FORMERS IN FOOD.

All the organs of the body contain the four elements, *Carbon*, *Hydrogen*, *Nitrogen*, and *Oxygen* : and no ingredients of food can be of use in building up the wasted parts of the body unless these four elements are present. The nutritive, or flesh-forming parts of food are called FIBRIN, ALBUMEN, and CASEIN : they contain the four elements in exactly the same proportions, and are found both in vegetable and in animal food. Fibrin may be got either by stirring fresh-drawn blood, or from the juice of a cauliflower; Albumen or white of egg from eggs, from cabbage-juice, or from flour. Casein or Cheese exists more abundantly in peas and beans than it does in milk itself. Fibrin, Albumen, and Casein, whether they are got from vegetable or animal bodies, have the same composition as dried flesh and blood. The growth and support of an animal is now easily explained: when a flesh-eater, like the tiger, lives on the flesh of another animal, it eats, in a chemical point of view, the substance of its own body, and requires only to give it a new place and form. When a child receives its mother's milk, it does the same thing, eating in fact its mother, and giving her flesh a new place and form on its own body. The nutrition of vegetable feeders is precisely the same : they find in Vegetable Fibrin, Albumen, and Casein the substance of their flesh and blood actually formed, and have only to give it a place and position within their bodies. Vegetables are the true makers of flesh : animals only arrange the flesh which they find ready formed in vegetables. The *nutritive* value of food depends upon its richness in flesh-forming matter. An adult man, in vigour, wastes five ounces of dry flesh daily, and requires the same amount of flesh-formers in his food.

Case 25 contains specimens of these substances obtained from various sources, and is accompanied with the following label :—

FLESH-FORMERS.

The bodies which form the basis of flesh, or any other organized part, are included under the popular name of "Flesh-formers ;" although in reality, besides these, water,

fat, and mineral matter are found in flesh, and are, in one sense, necessary to its formation. A piece of clean muscular fibre, or dry blood, free from water, fat, and mineral matter, has the same composition as either ALBUMEN, FIBRIN, or CASEIN, whether they are obtained from substances of Vegetable or Animal origin. 100 parts contain:—

CARBON	- -	54·0
HYDROGEN	- -	7·0
NITROGEN	- -	15·5
OXYGEN	- -	23·5

The Case shows these *staminal* ingredients of food, or "flesh-formers." They are all probably identical in their true *organic* parts.

1. ALBUMEN, made from Eggs and from Blood. It forms about 7 parts in 100 of blood, and is always present in lymph and chyle. Liquid or soluble albumen, as shown in the white of egg, coagulates by heat and various chemical agents.

2. ALBUMEN, as found in the juices of carrots, turnips, and cabbages, and obtained by boiling their juices. It is the same body as albumen from eggs.

3. FIBRIN made by stirring blood with a rod. It is the basis of muscle or flesh. Flesh-fibrin probably bears the same relation to blood-fibrin as coagulated albumen does to soluble albumen.

4. FIBRIN made from Wheat-flour. It is identical with the fibrin found in flesh, but not exactly the same as that found in blood, and is known as *Gluten*.

5. CASEIN prepared from milk, in which it is soluble, owing probably to a little alkali: when an acid is added, the Casein curdles or coagulates, and then is known as Cheese. In 100 parts of cows' milk there are $3\frac{1}{2}$ parts of Casein.

6. CASEIN or LEGUMIN as found in peas, beans, lentils, coffee, &c. The Casein of Vegetables is now supposed by most chemists to be identical with the Casein or Cheese of Milk, but a few chemists still deny this. 100 parts of peas contain above 20 parts of Casein.

The flesh-formers are most abundant in those plants which yield the substantive food of man. These plants

belong principally to the group of cereal grasses and leguminous plants. Of these the most important is Wheat The following label is exhibited in the Museum :—

WHEAT.

(Species(?) of the genus *Triticum.*)

The plants yielding Wheat belong to the natural order of Grasses (*Graminaceæ*). They have never been found in a perfectly wild state, and on that account have been supposed to originate in some other form of Grass at present wild. Although surmises have been made that the wheats originate in a wild plant called *Ægilops ovata,* the fact of the conversion of one into the other has not yet been proved. The Wheat plant is grown all over the world, but flourishes mostly between the parallels of 25 and 60 degrees of latitude. It is more abundant in the northern than in the southern hemisphere.

The varieties of Wheat cultivated in Europe may be divided into those whose flowers produce awns, and those without these appendages, or *bearded* and *beardless* Wheats. The fruits or seeds of these varieties are red or white, hence a further subdivision takes place into *red* or *white*, bearded or beardless, Wheats. Amongst the red bearded varieties is the fingered Egyptian or Mummy Wheat, which presents the peculiarity of several branches bearing fruits proceeding from its central stalk. Wheat is also called hard and soft according to its consistence, and winter and spring as it is sown at those seasons of the year. The red varieties yield the largest amount of grain, but the white the whitest flour.

Wheat is preferred to the other Cereal grasses as an article of food on account of its containing a larger quantity of flesh-forming matters. The flour also may be rendered very white by separating it from the husks, or bran, and the fruit is much more easily separated from the chaff than is the case with the other Cereals. The proportion of flesh-forming matters to those which give heat are more nearly adjusted to the requirements of the system in Wheat than in any other food. Hence, probably, its very general use as an article of food amongst the populations of the hardest-working nations in the world.

The quantity of Wheat-corn grown annually in the United Kingdom has been calculated at 14,000,000 of quarters.

In 1852, 8,000,000 of quarters of Wheat were imported into this country, exclusive of flour, meal, sago, rice, and other grain.

Case 26 contains an analysis of the various constituents contained in a pound of Wheat. The Table containing the analysis is subjoined:—

WHEAT.

(*Triticum.*)

Good Wheat should give three-fourths of its weight of fine flour; but the Chemical Composition of this depends upon the greater or less quantity which it contains of the outer husks. The finest flour is not so rich in flesh-forming matter as the coarser kinds. The average composition in 100 parts may be taken as:—

Water	14·0.	or,	WATER	14·0.
Gluten	12·8.		FLESH-FORMERS	14·6.
Albumen	1·8.		HEAT-GIVERS	69·8.
Starch	59·7.		MINERAL MATTER	1·6.
Sugar	5·5.			
Gum	1·7.			
Fat	1·2.			
Fibre	1·7.			
Ashes	1·6.			

1. Wheat, of which the Chemical Composition varies according to the varieties; 21 oz. required to make 1 lb. of flour.
2. Bran, or outer and inner skins of the wheat—5¼ oz.
3. Flour, or the inner part of wheat separated from the outer parts or bran—16 oz.
4. Water from 1 lb. of flour—2¼ oz.
5. Gluten from 1 lb. of flour—2 oz.
6. Albumen from 1 lb. of flour—¼ oz.
7. Starch from 1 lb. of flour—9½ oz.
8. Sugar from 1 lb. of flour—1 oz.
9. Gum from 1 lb. of flour—¼ oz.
10. Fat from 1 lb. of flour—⅛ oz.
11. Fibre from 1 lb. of flour—¼ oz.
12. Ashes from 1 lb. of flour—¼ oz.
13. *Carbon from 1 lb. of flour*—7 *oz.*

Cases 27, 28, 29, and 30 contain a variety of products obtained from Wheat and Wheat-flour. In certain forms of disease it is important to administer the gluten without the starch of Wheat, and such preparations will be found in Case 29. Maccaroni, Vermicelli, Semolina, and "Farinaceous foods" are prepared from Wheat-flour.

BARLEY.

(Hordeum distichion.)

Next in importance to Wheat amongst the cultivated grains of this country is Barley. Its great consumption is in the manufacture of Malt (Case 54), for the purpose of making Beer. In Case 31 the results of its analysis are given, to which the following label is attached :—

BARLEY.

(Hordeum.)

In Chemical Composition, Barley and Wheat are much alike; but Barley does not form such a fine and spongy bread as Wheat, although it is equally nutritive: 100 parts contain,—

Water	14·0.
Gluten	12·8.
Starch	48·0.
Sugar	3·8.
Gum	3·7.
Fat	0·3.
Fibre	13·2.
Ashes	4·2.

or,

WATER	14·0.	
FLESH-FORMERS	13·0.	
HEAT-GIVERS	69·5.	CARBON 40·0.
MINERAL MATTER	3·5.	

The Case shows the quantities of these ingredients found in 1 lb. of Barley.

1. Barley containing 14 parts of water—1 lb.
1a. Pot Barley got from 1 lb. of barley—11⅕ oz.
2. Water obtained from 1 lb. of barley—2⅓ oz.
3. Gluten obtained from 1 lb. of barley—2¼ oz.
4. Starch obtained from 1 lb. of barley—7½ oz.
5. Sugar obtained from 1 lb. of barley—½ oz.
6. Gum obtained from 1 lb. of barley—⅓ oz.
7. Fat obtained from 1 lb. of barley—$\frac{1}{16}$ oz.
8. Fibre obtained from 1 lb. of barley—2⅓ oz.
9. Ashes obtained from 1 lb. of barley—½ oz.
10. *Carbon in 1 lb. of barley—6½ oz.*

In Case 32 are some of the preparations of Barley. Barley Meal was formerly much used in this country for making barley cakes, and at the present day barley flour is found to be a useful, nutritious food for children, on account of its laxative action. When the outer coat is removed from the barley corn it is called Pearl Barley, and in this form it is used to some extent as an article of food.

Of all grain grown in this country, Barley yields the most certain and abundant crop. It bears the cold of this climate and yields a large crop where wheat would fail, on account of the dryness and poverty of the soil.

OATS.

(*Avena sativa.*)

This plant flourishes in the northern parts of the British Islands, and appears to originate in the wild oat (*Avena fatua*). It is not much used in England as food for man, but in Scotland it is largely consumed. In nutritive qualities it equals Wheat, but is not so agreeable or digestible. Its analysis is presented in Case 36, and accompanied with the following label:—

OATS.

(*Avena.*)

Oats, in the form of Oatmeal, are rich in flesh-formers and heat-givers, and serve as a nutritious and excellent diet, when the occupation is not sedentary. The outer husk of Oats, unlike Wheat, is poor in flesh-formers, so that oatmeal is better than the whole oat as food. In making oatmeal, one quarter of oats (328 lbs.) yields 188 lbs. of meal and 74 lbs. of husks; the rest being water. Oatmeal is remarkable for its large amount of fat. 100 parts contain:—

Water -	13·6.
Flesh-formers	17·0.
Starch -	39·7.
Sugar -	5·4.
Gum - -	3·0.
Fat - -	5·7.
Fibre - -	12·6.
Mineral matter	3·0.

or,

WATER - -	13·6.	
FLESH-FORMERS	17·0.	
HEAT-GIVERS -	66·4.	CARBON 43·0.
MINERAL MATTER	3·0.	

1. Shows 1 lb. of Oats with the usual husk.
2. 1 lb. of oatmeal of which about 57 per cent. is obtained from oats.
3. Water in 1 lb. of oatmeal—$2\frac{1}{8}$ oz.
4. Flesh-formers in 1 lb. of oatmeal—$2\frac{3}{4}$ oz.
5. Starch in 1 lb. of oatmeal—$6\frac{1}{3}$ oz.
6. Sugar in 1 lb. of oatmeal—$\frac{7}{8}$ oz.
7. Gum in 1 lb. of oatmeal—$\frac{1}{2}$ oz.
8. Fat or oil in 1 lb. of oatmeal—$\frac{7}{8}$ oz.
9. Fibre in 1 lb. of oatmeal—2 oz.
10. Ashes in 1 lb. of oatmeal—$\frac{1}{2}$ oz.
11. *Carbon in 1 lb. of oatmeal*—$6\frac{4}{5}$ *oz.*

Case 36 contains various preparations of oats, consisting of various forms of oatmeal and groats. The latter are employed for the preparation of gruel, a light diet much used in the sick room. The oatmeal, when mixed with water and heated, is called "Porridge," which is the form in which it is eaten by the Scotch. Oatmeal is also made into cakes, and in this form is consumed in Lancashire and Yorkshire as well as Scotland.

The Wall Cases numbered from 95 to 106 contain a series of specimens of Wheat, Barley, and Oats in the straw. These specimens represent the different varieties of these grains which are cultivated in Great Britain. They were presented to the Museum by Messrs. Peter Lawson and Co., of Edinburgh, to whom also the Museum is indebted for a series of models of cultivated roots in Case 83.

The Wall Cases also contain specimens of wheat grain from various parts of the world, exhibited at the Great Exhibition of 1851.

MAIZE, OR INDIAN CORN.

(*Zea Mays.*)

This cereal is a native of the New World, where it is extensively cultivated both in the United States and South America. It is also cultivated in the south of Europe and other parts of the world; although it sometimes ripens and attains maturity in this country, it cannot be relied on as a crop. Some fine specimens grown in England

are exhibited near Case 33, which contains an analysis of the grains. It is accompanied by the following label:—

Maize, or Indian Corn.

Maize yields a large return of food on a given extent of land. It contains less flesh-forming matter than other cereals, but is rich in heat-givers, and consequently has remarkable fattening qualities. 100 parts contain :—

Water -	- 14·0.	or,	Water -	- 14·0.	
Gluten -	- 12·0.		Flesh-formers	12·0.	
Starch -	- 60·0.		Heat-givers -	- 73·0.	Carbon 36·4.
Sugar - / Gum -	- 0·3.		Mineral matter	1·0.	
Fat -	- 7·7.				
Fibre -	- 5·0.				
Mineral matter	1·0.				

The Case shows the ingredients in 1 lb. of Maize, or Indian Corn.

1. Shows 1 lb. of Maize, or Indian corn.
2. 1 lb. of Indian meal.
3. Water in 1 lb. of Indian meal—2 oz. 105 gr.
4. Gluten in 1 lb. of Indian meal—1 oz. 402 gr.
5. Starch in 1 lb. of Indian meal—9 oz. 262 gr.
6. Sugar and gum in 1 lb. of Indian meal—21 gr.
7. Fat or oil in 1 lb. of Indian meal—1 oz. 101 gr.
8. Woody fibre in 1 lb. of Indian meal—350 gr.
9. Ashes in 1 lb. of Indian meal—70 gr.
10. *Carbon in 1 lb. of Indian meal—5¾ oz.*

It contains a larger quantity of fat or oil than the other cereal grains. It does not, however, contain so much nutritious matter. It is consumed largely as a food in the New World. The flour is called "hommony." It is made into bread, and cooked in the same manner as the wheat flour of Europe. Cases 34 and 35 contain varieties of the Maize, with meal and flour of the same.

RYE.

(*Secale cereale.*)

Rye was formerly extensively cultivated in this country. It is still much grown in the north of Europe, and rye

bread is a favourite diet of the people in that part of the world. It is subject to a disease which gives the grains a spined or horned appearance. These grains are produced by the attacks of a fungus, and are called Ergot of Rye. The ergot is used medicinally, and when taken as a food it produces poisonous effects. Rye yields a very nutritious flour, and when made into bread assumes a dark brown appearance. Hence it is called "black bread." Although Rye contains more starch and sugar than barley it is not used for fermentation, on account of the rapidity with which it passes into an acid condition. Rye bread is sour to the taste on this account. The following is an analysis of Rye as exhibited in Case 38 :—

Rye.

(*Secale.*)

Rye is grown much more in Germany, Russia, and Norway than in England. In composition it more resembles Wheat than either Oats or Barley. Rye, like Wheat, forms a light spongy bread. One hundred parts of Rye contain :—

Water - - -	13·00.
Gluten - - -	10·79.
Albumen - -	3·04.
Starch - - -	51·14.
Gum - - -	5·31.
Sugar - - -	3·74.
Fat - - - -	0·95.
Woody Fibre -	10·29.
Mineral matter	4.

or,

Water - - -	13·0.
Flesh-formers	13·8.
Heat-givers -	71·5–Carbon.
Mineral matter	1·7.

1. 1 lb. of Rye.
2. Water in 1 lb. of Rye—2 oz. 35 gr.
3. Gluten in 1 lb. of Rye—1 oz. 318 gr.
4. Albumen in 1 lb. of Rye—213 gr.
5. Starch in 1 lb. of Rye—8 oz. 79 gr.
6. Gum in 1 lb. of Rye—371 gr.
7. Sugar in 1 lb. of Rye—262 gr.
8. Fat in 1 lb. of Rye—66 gr.
9. Fibre in 1 lb. of Rye—1 oz. 284 gr.
10. Mineral matter in 1 lb. of Rye—122 gr.

MILLET.

(Species of *Sorghum* and *Setaria*.)

Under the name of "Millet," the grains of various species of grasses are eaten in Europe, Africa, and Asia. The grains are very small, but this is compensated for by the abundant produce of each panicle of the plant. These seeds are very nutritious, and form the principal diet of large populations in the countries where Millet is grown. They are prepared for eating in various ways. Sometimes the seeds are simply parched and eaten; at other times they are soaked in water, and made soft before eating. The husk is also removed, and the flour prepared in various ways, as with the other cereals.

BEANS.

(*Faba vulgaris, Phaseolus vulgaris, and P. multiflorus.*)

Although the various species of Beans are more used for feeding the lower animals than as human food, they nevertheless contain a larger quantity of nutritive matter, in proportion to their weight, than any of the cereal grains. The form the protein assumes in Beans is that of caseine. When this substance is introduced into the stomach in an insoluble form, it appears to be much less digestible than either albumen or fibrine. This may account for the fact that the seeds containing this substance are not so generally used for human food as the grains of the cerealia. Case 40 contains the constituents of a pound of Beans, of which the following label gives the particulars:—

BEANS.

(*Faba.*)

Beans, like other leguminous plants, are rich in flesh-formers; they therefore require to be mixed with a less nutritious substance to make them a wholesome diet. One hundred parts of field beans contain:—

Water - -	14·8.
Casein, or cheese	24·0.
Starch - -	36·0.
Sugar - -	2·0.
Gum - -	8·5.
Fat - -	2·0.
Woody Fibre	9·2.
Mineral matter	3·5.

or,

WATER - -	14·8.	
FLESH-FORMERS	24·0.	
HEAT-GIVERS -	57·7.	CARBON 36·0.
MINERAL MATTER	3·5.	

The Case shows the ingredients in 1 lb. of Beans.

1. 1 lb. of Beans.
2. Water in 1 lb. of Beans—2 oz. 161 gr.
3. Casein in 1 lb. of Beans—3 oz. 368 gr.
4. Starch in 1 lb. of Beans—5 oz. 333 gr.
5. Sugar in 1 lb. of Beans—140 gr.
6. Gum in 1 lb. of Beans—1 oz. 157 gr.
7. Fat in 1 lb. of Beans—140 gr.
8. Woody fibre in 1 lb. of Beans—1 oz. 206 gr.
9. Mineral matter in 1 lb. of Beans—245 gr.
10. *Carbon in 1 lb. of Beans—5¾ oz.*

Cases 41, 42, 43, 44, contain varieties of beans which are eaten in various parts of the world. These specimens were exhibited at the Great Exhibition of 1851.

The bean which is mostly eaten in Europe is the white Haricot bean (*Phaseolus vulgaris*). Before cooking, it should be soaked for 12 hours in cold water. It should then be boiled till it is soft. These beans may be safely eaten in small quantities, and contain a much larger proportion of nutrient matter than bread or potatoes and other vegetables.

Beans are also eaten green. This is the case with the large broad bean, which is very properly eaten with fat bacon; the beans supplying the flesh-forming matter, whilst the fat of the bacon supplies the heat-giving material. The fruit of the beans, when green, as in the case of the French beans (*Phaseolus vulgaris* and *P. multiflorus*), is also boiled and eaten. French beans may be preserved for winter use by placing in a vessel alternately layers of salt and beans.

PEAS.

(Species of *Pisum.*)

Peas, like beans, contain a large quantity of the flesh-forming principle, caseine, and apparently in a more digestible form.

Dried peas are more frequently used as an article of diet in this country than beans. When eaten alone and continuously they produce indigestion; but, on account of their highly nutritive character and low price, they may be advantageously added to other kinds of vegetable diet. They are frequently added to soup, and pea meal is made

into pudding, and eaten with boiled pork. A small quantity of pea meal may be added to wheat flour, whether in the manufacture of bread or puddings.

Case 45 contains an analysis of one pound of Peas, with the following label :—

PEAS.

(*Pisum.*)

Peas are rich in flesh-forming matter, in fact too rich as a simple diet, so that they are more wholesome when mixed with a less nutritive food like the potato. The flesh-former in peas is LEGUMIN, which most chemists now believe to be the same as CASEIN or Cheese. One hundred parts of Peas, air dried, contain :—

Water	14·1.	or,	WATER	14·1.
Casein, or Cheese	23·4.		FLESH-FORMERS	23·4.
Starch	37·0.		HEAT-GIVERS	60·0.
Sugar	2·0.		MINERAL MATTER	2·5.
Gum	9·0.			
Fat	2·0.			
Woody Fibre	10·0.			
Mineral matter	2·5.			

The Case shows the ingredients in 1 lb. of Peas.

1. 1 lb. of Peas.—1*a.* 1 lb. of Pease-flour.
2. Water in 1 lb. of Peas—2 oz. 112. gr.
3. Casein in 1 lb. of Peas—3 oz. 324 gr.
4. Starch in 1 lb. of Peas—5 oz. 403 gr.
5. Sugar in 1 lb. of Peas—140 gr.
6. Gum in 1 lb. of Peas—1 oz. 193 gr.
7. Fat in 1 lb. of Peas—140 gr.
8. Woody fibre in 1 lb. of Peas—1 oz. 263 gr.
9. Mineral matter in 1 lb. of Peas—175 gr.

Cases 46 and 47 contain varieties of Peas, and preparations of the common pea (*Pisum sativum*). The pea, like the bean, is eaten green, and large quantities are annually consumed in this country in this form.

The green pea contains more sugar and less caseine than the dried pea.

LENTILS.

(*Ervum Lens.*)

Lentils, like other leguminous seeds, contain much caseine. They are a favourite food in the East. The Hindoo adds

Lentils to his starch-giving rice, and obtains from them the nourishment the latter does not contain. The Lentil is not much cultivated in Great Britain, but the seeds are extensively employed on the continent of Europe. They enter into the composition of the prepared foods known by the name of "Erva Revalenta," and "Revalenta Arabica."

Case 48 contains an analysis of Lentils, and is accompanied with the following label:—

LENTILS.

(*Ervum Lens*).

Lentils are particularly nutritious, and are extensively used as food in various parts of the world. The food sold under the name of "Revalenta Arabica" is the meal of the Lentil after being freed from its outer skin, which is indigestible. The "red pottage" for which Esau sold his birthright appears to have been made of Lentils. One hundred parts contain, so far as is known,—

Water	14·0	or,	Water	14·0
Casein, or Cheese	26·0		Flesh-formers	26·6
Starch	35·0		Heat-givers	58·5
Sugar	2·0		Mineral Matter	1·5
Gum	7·0			
Fat	2·0			
Woody Fibre	12·5			
Mineral matter	1·5			

The Case shows the ingredients in 1 lb. of Lentils.

1. 1 lb. of Lentils.
2. Water in 1 lb. of Lentils—2 ozs. 105 grs.
3. Casein in 1 lb. of Lentils—4 ozs. 70 grs.
4. Starch in 1 lb. of Lentils—5 ozs. 262 grs.
5. Sugar in 1 lb. of Lentils—140 grs.
6. Gum in 1 lb. of Lentils—1 oz. 153 grs.
7. Fat in 1 lb. of Lentils—140 grs.
8. Woody Fibre in 1 lb. of Lentils—2 ozs.
9. Mineral matter in 1 lb. of Lentils—105 grs.

Case 49 contains preparations and varieties of Lentils.

The Chick Pea (*Cicer arietinum*) is another leguminous plant, the seeds of which are used especially in Spain as an

article of diet. They are also eaten in the East. They are generally prepared simply by parching. Parched peas are as common in the shops of Eastern countries as biscuits in England.

Many other kinds of leguminous seeds are also eaten in Turkey, Hindostan, and China.

In America, a small leguminous plant, the *Arachis hypogæa*, is extensively grown. It ripens its fruit under the ground; hence it is called earth-nut, or underground kidney-bean. The seeds contain much oil. They are parched and sold in the shops within their pods. (See Case 23.)

The green pods of *Lathyrus aphaca*, called in France *Vesce cultivé*, are eaten, but they are narcotic when ripe.

BUCKWHEAT.

(*Polygonum Fagopyrum.*)

This plant is known in this country by the name of "Brank," and is cultivated for the sake of its green fodder. On some parts of the continent of Europe the ripe seeds are ground and mixed with wheat flour, and eaten as human food. Birds are exceedingly fond of buckwheat, and one of the principal uses made of the seeds in this country is to feed pheasants in the winter. Case 50 contains the ingredients of a pound of Buckwheat, from which it will be seen that it does not contain so much flesh-forming matter as the cereal grains.

BUCKWHEAT.

(*Polygonum.*)

Although in composition Buckwheat does not rank in nutritive value so high as Wheat, Oats, or Barley, still its late sowing, rapid growth, and cheap cultivation, render it a valuable plant. 100 parts contain :—

Water - -	14·2.			
Gluten - -	8·6.			
Starch - -	50·0.		Water - -	14·2.
Gum - -	2·0.		Flesh-formers	8·6.
Sugar - -	2·0.	or,	Heat-givers ·	75·4.
Fat - -	1·0.		Mineral matter	1·8.
Woody Fibre	20·4.			
Mineral matter	1·8.			

The Case shows the ingredients in 1 lb. of Buckwheat.

1. 1 lb. of Buckwheat.
2. Water in 1 lb. of Buckwheat—2 oz. 118 gr.
3. Gluten in 1 lb. of Buckwheat—1 oz. 165 gr.
4. Starch in 1 lb. of Buckwheat—8 oz.
5. Gum in 1 lb. of Buckwheat—140 gr.
6. Sugar in 1 lb. of Buckwheat—140 gr.
7. Fat in 1 lb. of Buckwheat—70 gr.
8. Woody fibre in 1 lb. of Buckwheat—3 oz. 114 gr.
9. Mineral matter in 1 lb. of Buckwheat—126 gr.

Besides the plants above mentioned, many others contain a sufficient quantity of flesh-forming matter to nourish the human system, and form when mixed with animal diet excellent adjuncts in human food. As these have not yet been submitted to chemical analysis, it is impossible to say how far they are adapted to form substantive articles of human diet.

As it is of importance to ascertain the amount of nutritive matter contained in a given quantity of food, Cases 86, 87, and 88 have been arranged to present to the eye the quantity of commonly consumed articles of diet containing a given quantity of flesh-formers. The following label explains the contents of these cases:—

Equivalents of Food containing the same Supply of Flesh-formers.

In nutrition, the tissues of the body can only be produced by the agency of "Flesh-formers," already the same in composition as the flesh to be formed. Different kinds of food vary much in their amount of flesh-formers; some, as legumes (peas, beans, &c.), being rich in them; while others, as potatoes and carrots, are poor. An adult labouring man must have *five ounces* of flesh-formers supplied, daily, in food, to restore the waste of 5 oz. of the organic parts of his body. It becomes important to know what quantities of each kind of food he must consume to supply the normal waste of 5 oz., and what would be the cost to him of restoring the waste by the several kinds of food in common use. The different quantities of food here shown, all contain the same amount (5 oz.) of flesh-formers, and must be eaten as the day's supply to enable the labourer to do a day's work; their relative cost for restoring the daily waste of tissues is

the money paid in purchasing the amount exhibited. Experience, however, has taught man that he should mix food so as to ensure a proper balance between the heat-givers and flesh-formers, and not to depend upon one kind of food for the exclusive supply of either.

Five ounces of flesh-formers, being the amount required to restore the daily waste of the body, are contained in the quantities given of each of the following vegetable substances:—

1. Wheat Flour -	2 lbs.	1 oz.	average cost -	$4\frac{1}{2}$d.
2. Barley Meal -	2 lbs.	6 oz.	average cost -	$4\frac{1}{2}$d.
3. Oatmeal - -	1 lb.	13 oz.	average cost -	$4\frac{1}{2}$d.
4. Maize - - -	2 lbs.	9 oz.	average cost -	$7\frac{1}{2}$d.
5. Rye - - - -	2 lbs.	3 oz.	average cost -	6d.
6. Rice - - - -	4 lbs.	13 oz.	average cost 1s.	2d.
7. Buckwheat -	3 lbs.	10 oz.	average cost 1s.	
8. Lentils - - -	1 lb.	3 oz.	average cost -	$5\frac{1}{2}$d.
9. Peas (dry) - -	1 lb.	5 oz.	average cost -	$2\frac{3}{4}$d.
10. Beans (dry) -	1 lb.	5 oz.	average cost -	$2\frac{3}{4}$d.
11. Potatoes - -	20 lbs.	13 oz.	average cost -	7d.
12. Carrots - -	31 lbs.	4 oz.	average cost 2s.	6d.
13. Parsnips - -	15 lbs.	10 oz.	average cost 1s.	1d.
14. Turnips - -	17 lbs.	13 oz.	average cost 1s.	8d.
15. Cabbage - -	10 lbs.	6 oz.	average cost -	6d.
16. Tea (dry) - -	1 lb.	11 oz.	average cost 6s.	9d.
17. Coffee (dry) -	2 lbs.	1 oz.	average cost 2s.	9d.
18. Cocoa (nibs) -	3 lbs.	2 oz.	average cost 3s.	
19. Bread - - -	3 lbs.	13 oz.	average cost -	6d.

The construction of public dietaries is a matter of great importance. Unless a due proportion is maintained between the heat-givers and flesh-formers, disease and death may be the consequence. Cases 84 and 85 have been constructed to illustrate the quantity of food consumed in the public services and institutions of this and other countries.

The following labels explain their contents:—

Public Dietaries.

Case I.

The experience of Nations in the support of persons depending upon public diets, such as the Soldier, Sailor, Pauper, or Prisoner, gives data for determining the quantity of Flesh-formers and Heat-givers required for support under dif-

ferent conditions, however varied may be the substances composing the dietaries. This Case shows the amount of flesh-formers and of the Carbon (Charcoal) in the food of Soldiers and Sailors in different countries. Carbon is the element which chiefly determines the value of the heat-givers. As a general result, men in fighting condition require a daily supply of 5 or 6 oz. of flesh-formers, and 10 oz. of Carbon.

1. THE ENGLISH SOLDIER wastes, both in this country and in India, 5 oz. of his dry flesh or other tissues daily, and must have that amount of flesh-formers in food. This must also contain 10 oz. of carbon.

2. THE ENGLISH SAILOR wastes 5 oz. of his dry flesh or other tissues daily, and must receive 5 oz. of flesh-formers in food. He consumes 10 oz. of carbon daily.

2*a*. THE ENGLISH SAILOR in his Salt Meat dietary has nearly 6 oz. of flesh-formers daily, and 12 oz. of carbon. This may be necessary from the less nutritive nature of the food. The quantities appear to be too high.

3. THE DUTCH SOLDIER *when in war* wastes daily 5 oz. of flesh, and obtains that supply of flesh-formers in his food, along with $10\frac{1}{2}$ oz. of carbon.

3*a*. THE DUTCH SOLDIER *when in peace*, or in garrison, has a lower diet, in which there are only $3\frac{1}{2}$ oz. of flesh-formers, and 10 oz. of carbon. With this diet he is below fighting condition.

4. THE FRENCH SOLDIER, although his diet is of very different character from that of the English Soldier, still receives nearly the same amount of flesh-formers in his food, ($4\frac{3}{4}$ oz.) and 12 oz. of carbon. The French Soldier, unlike the Dutch Soldier, is thus always kept in fighting condition.

5. THE ROYAL ENGINEERS, now occupied in the Museum of South Kensington, are found to eat $4\frac{9}{10}$ oz. of flesh-formers and 13 oz. of carbon daily.

PUBLIC DIETARIES.

Case II.

In Case No. I. is shown the dietaries of Soldiers and Sailors when kept in fighting condition. When the Soldier returns to Chelsea Hospital or the Sailor to Greenwich Hospital for repose, he does not waste so much flesh, and therefore does not require to have such a large amount of flesh-formers in his food ; these are then reduced to between 3 and 4 ounces daily. The Carbon, however, remains high, perhaps higher than is necessary. Paupers in Workhouses, not being exposed to much labour, do not waste so much flesh ;

they require less flesh-formers in food than active Soldiers and Sailors. Boys 10 years of age, at School, receive about one half the flesh-formers of active men, and about three-fourths the quantity of carbon. Ladies, in luxurious repose, consume about the same amount as young Schoolboys.

1. GREENWICH PENSIONERS have $3\frac{1}{2}$ oz. of flesh-formers and 10 oz. of carbon in their daily supply of food.

2. CHELSEA PENSIONERS have 4 oz. of flesh-formers and $9\frac{3}{4}$ oz. of carbon in their food daily.

3. The OLD MEN of Gillespie's Hospital in Edinburgh have 3 oz. of flesh-formers and 10 oz. of carbon daily.

4. PAUPERS. Taking the average of all the Workhouses in the Kingdom, it is found that paupers have daily $3\frac{1}{7}$ oz. of flesh-formers and $8\frac{1}{4}$ oz. of carbon.

5. The BOYS of the Royal Naval School at Greenwich have $2\frac{1}{2}$ oz. of flesh-formers and $7\frac{1}{2}$ oz. of carbon in their food daily.

6. The BOYS of Christ's Hospital in London have $2\frac{1}{2}$ oz. of flesh-formers and 7 oz. of carbon in their food.

Cases 119, 120, 121, 122, and 123 are intended to present a summary of the quantities of Water, Mineral Matters, Heat-givers, Flesh-formers, and Accessories contained in one pound of several of the substances the analysis of which ha sbeen previously stated.

CLASS II. MEDICINAL OR AUXILIARY FOODS.

In the mixed food of man in all nations there are certain substances which are neither employed for the maintaining animal heat or the building up of the fabric of the body. Although consumed in large quantities, they cannot be regarded as necessary to life, as the animal body can be sustained independent of their use. They act upon the system as medicines, and may be regarded as auxiliaries to the necessary foods. Such are alcohol, volatile oils, acids, the alkaloids of tea, coffee, and tobacco, and the innutritious ingredients of animal and vegetable food, gelatine, woody fibre, and gum.

They may be classed, according to their action on the system, as stimulants, alteratives, narcotics, and accessories.

GROUP I. STIMULANTS.

These include the beverages containing alcohol, and the condiments and spices containing volatile oils.

Alcohol.

All things containing grape sugar, or substances convertible into grape sugar, are susceptible of fermentation. By this process the sugar is converted into alcohol. The following diagram explains the change.

One atom of grape sugar contains,

Carbon.	Hydrogen.	Oxygen.
12 atoms.	12 atoms.	12 atoms.

These are converted into two atoms of alcohol, containing,

Carbon.	Hydrogen.	Oxygen.
8 atoms.	12 atoms.	4 atoms.

and four atoms of carbonic acid gas, containing,

Carbon.	Hydrogen.	Oxygen.
4 atoms.	0	8 atoms.

	Carbon.	Hydrogen.	Oxygen.
Thus	12 atoms,	12 atoms,	12 atoms (grape sugar).
	8 atoms,	12 atoms,	4 atoms (alcohol).
	4 atoms,		8 atoms (carbonic acid).
	12	12	12

Ale, Beer, and Porter.

The most common form in which alcohol is employed as a beverage in this country is that of Beer. Case 54 contains the materials from which porter has been brewed, and in the jars surrounding it will be found illustrated the changes which occur in the malt during its conversion into beer.

These specimens have been supplied from Messrs. Huggins and Co., Brewery, Broad Street, Westminster. The following labels explain the specimens :—

Beers.

Beers consist of the infusions of certain plants partially fermented. In the process of making common or barley beer, the starch is first changed into grape sugar, and then into alcohol and carbonic acid. The malting, or sprouting, of barley converts a portion of the starch into grape sugar; the malt is then crushed, infused in water, and heated, a process which dissolves the soluble ingredients in the malt; a peculiar principle called Diastase, present in the malt, then proceeds in its action on the remaining portion of starch in the grain changing it into sugar: when this operation has proceeded far enough, it is stopped by boiling and the addition of hops, about 1 lb. of hops being used for a bushel of malt. The infusion or *wort*, being cooled, is fermented with yeast (which is a small growing plant or fungus), and a portion, about one quarter or one half, of the sugar passes into alcohol and carbonic acid. In common beer there is 1 per cent. of alcohol, in strong beer 4 per cent., in strong porter (stout) 6 per cent., and in the strongest ale 8 per cent.; in addition to the spirit there is sugar, starch, gum, and a little gluten. About 550 millions of gallons of beer are annually brewed in this country from malt.

Many other things besides malt are used for inferior beers, such as potatoes, beans, turnips, and other starchy foods. In Russia, rye furnishes *Quass* or rye-beer. The Tartars and Turks use *Koumis* or a beer made from fermented milk, generally mare's milk, which is richer in sugar than that of the cow; a pint of milk-beer contains about an ounce of spirit. Chica beer, largely used in South America, is chiefly made from maize, which old women chew, and when sufficiently masticated, spit into jars, where it is mashed with hot water, and fermented. Beers and beverages are also made from pine apples, rice, peas, seeds of the *Prosopis Algaroba*, &c. In the South Sea Islands, Ava, Cava, or Arva beer is made in a similar way from the intoxicating long pepper (*Macropiper Methysticum*), but only the young with good teeth are allowed to chew it, so as to prepare it for the king and nobles; it is said to taste like Gregory's Mixture. The action of the saliva, in these cases, is obviously to convert the starch of the plant into sugar; chewing in this case is a substitute for malting in England. Millet beers, made by the infusion and fermentation of millet seeds, are largely used by Eastern nations.

Specimens illustrative of the means employed in Brewing Beer and Porter.

1. Dry yellow barley for malting.

2. Dry white barley for malting.

3. Barley in its first stage of conversion into malt. The barley is placed in a cistern and wetted, which makes it begin to grow; it is then placed on the malting floor, when it soon assumes the appearance shown in this example, and is in its first stage of sprouting.

4. The malt six days old, when the sprout, or acrospire, is larger.

5. The malt ten days old, showing the still further growth of the acrospire.

6. The malt fourteen days old. It is now sufficiently sprouted, the starch of the barley being to a great extent converted into sugar by the action of a peculiar principle, called Diastase, which is present in the grain.

7. Malt in a finished state. The malt having sufficiently sprouted, as in No. 6, is dried in a kiln, and is then in a state fit for brewing.

8. Crushed malt, ready for infusion in water.

9. Brewers' grains, or the malt exhausted of its valuable ingredients. Grains are used by dairymen for fattening pigs, etc.

10. Hops from South and Middle Kent. These are added to the infusion of the malt.

11. Worcestershire hops.

12. Belgium hops used for making porter.

13. Spent hops. Hops after being boiled in the Wort are used as manure.

14. Yeast. Yeast is added to the infusion, or Wort, and causes it to ferment, and the saccharine matter to pass, more or less, into alcohol.

15. Roasted brown malt used for the darker Ales.

16. Roasted malt used as the colouring matter for porter.

17. Isinglass dissolved in sour beer, used for the fining or clearing of ale or beer.

18. Fourpenny Ale. The product of the previous processes.

19. London porter, which, when stronger, is called stout.

The following quantities are required to make three barrels of 4*d.* ale :—

1 quarter of malt.
8 lbs. of hops.
5 barrels of 36 gallons each of water.

In brewing, 1 barrel, or 36 gallons, is lost by evaporation; half a barrel, or 18 gallons, in the fermentation and racking; and half a barrel is absorbed by the grains.

The following analyses of Beers and Ales are presented to the eye :—

An Imperial Pint of the following beverages contains the following ingredients :—

	Water.	Alcohol.	Sugar.		Acetic Acid.
	ozs.	ozs.	ozs.	grs.	grs.
London Stout - -	$16\frac{1}{2}$	$1\frac{1}{2}$	0	281	54
London Porter - -	$17\frac{1}{4}$	$0\frac{3}{4}$	0	267	45
Pale Ale - - -	$17\frac{1}{2}$	$2\frac{1}{2}$	0	240	40
Mild Ale - -	$18\frac{3}{4}$	$1\frac{1}{4}$	0	280	38
Strong Ale - -	18	2	2	136	54

Wines.

Wines are prepared by the direct fermentation of the glucose contained in fruit. The wines of Europe are mostly prepared from the juice of the grape.

The juice before fermentation is called "Must." Wines vary according to the quantities of sugar, alcohol, and acid they contain. Wines with much sugar are called "sweet;" those with little, "dry." Sugar is frequently added to wines to cover their acid flavour. This is the case with orange, rhubarb, and other wines made in Great Britain. Where sugar is not added, the sweetness of wines depends on the fermentation not having exhausted the sugar.

The quantity of alcohol depends on the quantity of sugar changed during fermentation. It is frequently added to wines to give them strength. This is the case with port, sherry, and Madeira. Clarets, hocks, and the light wines of the Continent will not bear the addition of alcohol,

and they naturally contain less alcohol than port, sherry, and Madeira.

The acid in wines made from grapes is the tartaric. This acid forms an insoluble salt with potash, the super-tartrate of potash, or cream of tartar, which forms the tartar or lees of wine, and thus prevents the too great acidity of grape wines.

Wines made from apples and pears (cider and perry), and from oranges and other fruits, contain acids which are not thrown down; hence the necessity of adding sugar to cover their acidity.

The colour of red wines depends on very small quantities of colouring matter.

The difference of estimation in which wines are held, and their price, depends upon the development of a variety of curious chemical compounds during their fermentation and keeping, and which constitute what is technically known as their "bouquet" or flavour. Thus, independent of this bouquet, the highest-priced and lowest-priced wines are essentially the same.

The following Table gives the quantities of alcohol, sugar, and acid in some of the more commonly-consumed European wines:—

One Imperial Pint of the following wines contains:—

	Water.	Alcohol.	Sugar.		Tartaric Acid.
	ozs.	ozs.	ozs.	grs.	grs.
Port - - -	16	4	1	2	80
Brown Sherry - -	$15\frac{1}{2}$	$4\frac{1}{2}$	0	360	90
Pale Sherry - -	16	4	0	80	70
Claret - - -	18	2	—		161
Burgundy - -	$17\frac{1}{2}$	$2\frac{1}{2}$	—		160
Hock - - -	$17\frac{3}{4}$	$2\frac{1}{4}$	—		127
Moselle - -	$18\frac{1}{4}$	$1\frac{3}{4}$	—		140
Champagne - -	17	3	1	133	90
Madeira - - -	16	4	0	400	100

The beverages made from the juice of apples and pears, and known by the names of Cider and Perry, contain malic instead of tartaric acid.

An Imperial Pint of Cider contains:—

Water - - - - - -	19 oz.
Alcohol - - - - -	1 oz.
Sugar - - - - - -	400 gr.
Malie Aeid - - - -	120 gr.

Distilled Spirits.

When wines or other fermented liquors are submitted to heat, the aleohol distils over, and may be collected in a receiver. The produet thus obtained is called Distilled Spirits. The alcohol is not, however, pure, but mixed with water. It is difficult to procure alcohol pure; and distilled spirits always eontain a eertain quantity of water. A spirit having a density of 825 is ealled proof spirit in this eountry; and when distilled spirits contain more or less aleohol than this, they are said to be "under" or "above" proof. Alcohol is obtained for commereial uses in this eountry from malt. When employed in the arts it has no speeial flavour, and is called "Spirits of Wine."

Gin is obtained from fermented grain. to whieh the berries of the Juniper (*Juniperus communis*) are added to give it a flavour. Other flavouring substanees are employed, as cinnamon, eloves, &c., for what is ealled "Cordial Gin." The words Gin and Geneva are a corruption of *Genièvre*, French for Juniper.

Whisky is distilled from grain, and has a slight smoky flavour whieh gives it its peculiar taste.

Rum is distilled from fermented sugar and molasses in the West Indies, and its flavour is given by the addition of pine apples.

Brandy is distilled from wine, and its peeuliar flavour depends on the addition of peach kernels to the liquid whilst distilling.

Arrack is obtained from fermented rice or betel-nuts.

Potato-Brandy is made by eonverting the stareh of the potato into glueose and then fermenting and distilling.

Liqueurs are spirits distilled from various substanees which give their peculiar flavour, and to which a considerable quantity of sugar is added.

The following is an analysis of the quantity of alcohol, water, and sugar in Brandy, Rum, and Gin:—

	Water.	Alcohol.	Sugar.	
	ozs.	ozs.	ozs.	grs.
Brandy - - -	$9\frac{1}{2}$	$10\frac{1}{2}$	0	80
Gin, best - - -	12	8	—	
Gin, retail - - -	16	4	$\frac{1}{2}$	0
Rum - - - - -	5	15	—	

Distilled Spirits obtained from grain contain a substance called Fusel Oil, which acts very injuriously on the human system. Potato Spirit contains an analogous oil. Brandy like wine contains œnanthic and acetic ether. Rum owes its flavour to butyric ether.

It is well known that although alcohol is taken in large quantities by the human family, that it is an agent exceedingly destructive to human health and life. When taken into the stomach it acts upon the mucous membrane, and when absorbed into the blood it acts upon the nervous system. When taken in too large quantities in any of its forms, or upon an empty stomach, it lays the foundation of diseases of the stomach and surrounding organs, which often terminate in death. Its action on the nervous system, though pleasant and agreeable, and even healthful in small quantities, becomes a source of fearful disease when carried to excess. The physical degeneracy and moral degradation attendant upon taking alcohol in excess are well known; and no language is too strong to condemn the folly and wickedness of those who thus convert one of the blessings of Providence into a curse.

Not only is the drinking alcohol to excess injurious to the individual, but it is as wasteful as it is injurious. The quantity of grain required to supply the average quantity of alcohol drunk by the population of Great Britain would supply a working man with heat-giving and flesh-forming food for forty days. The quantity of alcohol, $3\frac{3}{4}$ gallons, thus consumed, and the quantity of barley destroyed to supply it, are exhibited on the table with the beers and wines.

The ulterior action of alcohol on the system is a question of considerable physiological interest. By some it has been regarded as a heat-giver; its carbon and oxygen being supposed to be oxidised in the system and thrown out as carbonic acid gas and water. In accordance with this view it has been arranged in the Museum with the heat-givers. On the other hand, it has been maintained that it diminishes the excretion not only of carbonic acid but of the nitrogenous matters which are thrown off from the system. According to the results of a recent series of experiments,* rum has the power of increasing the quantity of carbonic acid expired, whilst brandy, gin, and whisky decrease it.

Condiments and Spices.

There is a large class of substances which are added to food for the purpose of giving it flavour, and which, on account of the volatile oils they contain, act as stimulants. When taken into the stomach, like alcohol, they excite the mucous membrane and also stimulate the nervous system. These substances are known as Spices and Condiments. They also serve as the basis of a large number of the sauces which are sold prepared for the purpose of being added to cooked foods.

The *Spices* include cinnamon, cassia, bark, cloves, allspice, ginger, nutmeg, mace, and cardamoms.

The *Condiments* include Cayenne and black pepper, mustard, mint, sage, and the fruits of the Umbelliferæ, as carraways, coriander, fennel, cummin, and aniseed.

A series of these substances have been arranged in Cases 55, 56, 57, 58, and 59.

GROUP II. ALTERATIVES.

Two classes of substances have been arranged under this head as expressive of their influence on the blood, without indicating their special action. It embraces the various

* Dr. Edward Smith.

kinds of acids, and the alkaloids, more especially those found in tea, coffee, and chocolate.

a. Acids.

The acids most commonly used in the diet are,

Acetic acid.
Citric acid.
Tartaric acid.
Malic acid.
Oxalic acid.

As articles of diet they probably all act in the same manner on the system. They all exert a solvent power over mineral substances, and assist in carrying the alkalies and alkaline earths into the blood. There is also reason to believe that in certain states of the system they favour the development of the gastric juice in the stomach, and assist by their decomposition in oxidising the materials of the blood. In all cases they act medicinally or as auxiliaries to the first class of foods.

Acetic Acid, or Vinegar is obtained either from the oxidation of alcohol in fermented liquors, or from the distillation of wood. Common vinegar is obtained from the oxidation of the fermented wort of malt. A series of preparations illustrating the processes undergone in the formation of vinegar has been presented to the Museum by Messrs. Beaufoy & Co.

The basis of vinegar consists of acetic acid, which is composed of carbon, hydrogen, and oxygen; the same elements that enter into the composition of alcohol. This compound is also procured from the distillation of wood. The acetic acid thus procured is called pyroligneous acid. The quantity of acetic acid in vinegar is from 4 to 5 per cent. Malt vinegar contains, besides acetic acid, water, dextrin, and frequently sulphuric acid. Wine vinegar contains, besides acetic acid, the constituents of the wine from which it is made, as tartaric acid, &c. Pure vinegar is transparent, but burnt sugar is added to give it a colour, on account of a popular prejudice in favour of coloured vinegar.

Vinegar is frequently added to sauces and food to give them a flavour. It also preserves vegetable substances from decomposition, and is used in the manufacture of what are

called "Pickles." Various kinds of fruits, leaves, and parts of plants are thus preserved and added to food. Some things are used in this way which are not otherwise employed. This is the case with the caper, which is the fruit of the *Capparis spinosa;* and the sterchion, the fruit of the Indian Cress (*Tropæolum majus*). A collection of fruits and plants preserved in vinegar will be found on the shelves devoted to the exhibition of "acids."

Citric Acid is contained in many fruits, but exists in greatest abundance and purity in the fruits of the Orange tribe, the natural order Aurantiaceæ (Case 60). This order embraces the orange, the lemon, the citron, the shaddock, the pomelot, the lime, and others. All these fruits contain citric acid, and varying proportions of sugar. Citric acid can be separated from the juice of these plants in a crystalline form.

The rind of these fruits contains a stimulant volatile oil, which is used under the name of Oil of Lemons and Neroli Oil. It is also prepared with sugar in various ways, and brought to table. The flowers of the Orange yield a delicious perfume.

The edible products of the Orange tribe are exhibited in Case 60. There are also specimens of the monstrous varieties which the fruits of this tribe assume.

The juice of these fruits is employed in the Navy for the purpose of preventing scurvy amongst sailors. This effect has been attributed solely to the citric acid, but it has been found that the acid alone does not act so efficaciously as when contained in the juice of the fruit. Hence some writers have attributed the effect to a chemical compound of the acid with other ingredients of the juice.

Citric acid is also found in many fruits, but mixed with other acids, as in the Barberry, Strawberry, &c.

Tartaric Acid is found in the juice of the fruits of the Vine tribe (*Vitaceæ*), more especially of the common Vine (*Vitis vinifera*). This acid gives the acidity to the fruit of the grape, and is the acid present in wines. It forms with potass an insoluble salt, known by the name of cream of tartar. This salt is found in the lees of wine. By burning,

tartaric acid is converted into carbonic acid, and thus salt of tartar (carbonate of potash) is made from the tartar of wine. Hence also the name Tartaric Acid. In Case 21 is a series of dried fruits of the Grape (*Vitis vinifera*). They are known by the name of "raisins." and "currants."

Malic Acid is contained in the fruits of the Rose tribe, natural order Rosaceæ. It has the same general properties as the other acids, and is contained alone in apples and pears, whilst in cherries, plums, &c. it is mixed with other acids.

The edible products of the natural order Rosaceæ, comprising the fruits of the Apple, Pear, Apricot, Nectarine, Peach, Cherry, Plum, Raspberry, Strawberry, are exhibited in Case 107. They are mostly preserved in sugar. Many forms of plums called Prunes contain a sufficient quantity of sugar to be dried and preserved without further preparation.

Oxalic Acid is contained in the Wood Sorrel (*Oxalis acetosella*), also in the common Sorrel (*Rumex acetosa*) and various species of Rhubarb (*Rheum*). Species of the latter genus are extensively cultivated in this country, and the petioles of their large leaves cut up and made into pies, puddings, &c. They are ready for use early in the spring, and are an excellent substitute for fruit in pies and tarts at that season of the year. Although oxalic acid is a poison when taken in large quantities, as ordinarily consumed it probably acts in the same way as other acids on the system.

Many other fruits, as the Currant, Gooseberry, Cranberry, Whortleberry, Bilberry, and Blackberry, are consumed on account of their pleasant acid and sweet flavour.

b. ALKALOIDS.

These substances are more especially contained in tea, coffee, and chocolate. Tea and coffee have hardly any other properties in common than the possession of an alkaolid called caffeine or theine, which is identical in the two. Chocolate contains a peculiar alkaloid, theobromine; but the only other substance used extensively for a dietetic infusion, the Paraguay tea, contains theine.

Tea.—Cases 61 and 62 contain the analysis of tea, and a large series of varieties of this extensively employed substance.

The following explanatory labels accompany this collection :

TEA.

(*Thea Sinensis.*)

Tea consists of the leaves of several varieties of a small shrub found in China and India. The leaves are gathered in the fourth year of the growth of the plant, which is generally dug up, and renewed in its tenth or twelfth year. The leaves are cropped with care by gatherers who wear gloves, wash frequently, and avoid eating things likely to affect the breath. The differences between Teas result partly from the varieties of soil and growth; but also from the mode of curing and drying the leaves. Black Tea consists of leaves slightly fermented, washed, and twisted. Genuine green tea is made of exactly the same leaves, washed and twisted, without fermentation ; but commercial "green" teas are often black teas coloured with Prussian blue. Probably five hundred millions of men, or half the human race, now use tea. In the United Kingdom, above 29 thousand tons, or 65 millions of pounds, are annually used; or about 2 lbs. for every person in the Kingdom. The chief action of tea depends, firstly, on its volatile oil (less in old than in new teas), which is narcotic and intoxicating; and, secondly, on a peculiar crystalline principle, called THEINE. Theine excites the brain to increased activity; but soothes the vascular system by preventing rapid change or waste in the fleshy parts of the body, and so economises food. Four grains of *Theine*, contained in half an ounce of tea, act in this way ; but if one ounce of tea, containing 8 grains of Theine, be taken in a day by one person, then tremblings, irratibility of temper, and wandering of thoughts, ensue. When the system becomes thus saturated with Theine, it is useful to resort to Cocoa as a beverage, for a few days, when the irritable symptoms subside and the use of Tea may be renewed.

Tea.

(*Thea Sinensis.*)

The Tea-leaves, which become changed in the process of drying and preparation, resemble Coffee in many points. They are rich in casein or cheese, but contain in the same weight nearly twice as much Theine as Coffee. The aromatic oil, which by itself is intoxicating, is present in greater quantity than in coffee. One hundred parts of good Tea contain:—

Water	5·00.
Theine	3·00.
Casein or Cheese	15·00.
Aromatic Oil	0·75.
Gum	18·00.
Sugar	3·00.
Fat	4·00.
Tannic Acid	26·25.
Fibre	20·00.
Mineral Matter	5·00.

or,

Water	5·0.
Flesh-formers	18·0.
Heat-givers	72·0.
Mineral Matter	5·0.

In an ordinary infusion of Tea, the flesh-formers remain with the leaves; but may be taken up by Soda in the water. Hence the practice of the poor of adding Soda to the water in making Tea extracts much of its nutritive ingredients. The Case shows the ingredients in 1 lb. of good Tea.

1. Water in 1 lb. of Tea—350 gr.
2. Theine in 1 lb. of Tea—210 gr.
3. Casein in 1 lb. of Tea—2 oz. 175 gr.
4. Aromatic Oil in 1 lb. of Tea—52 gr.
5. Gum in 1 lb. of Tea—2 oz. 385 gr.
6. Sugar in 1 lb. of Tea—211 gr.
7. Fat in 1 lb. of Tea—280 gr.
8. Tannic Acid in 1 lb. of Tea—4 oz. 87 gr.
9. Woody Fibre in 1 lb. of Tea—3 oz. 87 gr.
10. Mineral Matter—350 gr.

TABLE, showing the RELATIVE CONSUMPTION of TEA in different COUNTRIES.

Country.	Annual Consumption in Ounces per Head of the Population.
UNITED KINGDOM - - -	$35\frac{1}{4}$
FRANCE - - - -	1
ZOLLVEREIN - - - -	$\frac{1}{2}$
RUSSIA - - - -	4
UNITED STATES - - -	16

In Case 63 is contained a specimen of the Paraguay Tea, with the following label :—

PARAGUAY TEA, OR MATÉ.

(*Ilex Paraguayensis.*) Nat. Ord. AQUIFOLACEÆ.

The Maté occupies the same important position in the domestic economy of South America as the Chinese Tea (*Thea Sinensis*) does in this country. The leaves of the Maté Plant, a species of holly (*Ilex Paraguayensis*), are from four to five inches in length, and are prepared by drying and roasting, not in the manner of the Chinese Teas, in which each leaf is gathered separately, but large branches are cut off the plants and placed on hurdles over a wood-fire until sufficiently roasted ; the branches are then placed on a hard floor and beaten with sticks ; the dried leaves are thus knocked off and reduced to a powder, which is collected, made into packages, and is ready for use. There are three sorts known in the South American markets: the Caa-Cuys, which is the head of the leaf ; the Caa-Miri, the leaf torn from its midrib and veins, without roasting ; and the Caa-Guaza or Yerva de Palos of the Spaniards, the whole leaf, with the petioles and small branches roasted. The method of preparing it for drinking is by putting a small quantity, about a teaspoonful, into a gourd or cup, with a little sugar; the drinking tube is then inserted, and boiling water poured on the Maté ; when sufficiently cool to drink without scalding the mouth, the infusion is sucked up through the tube. It has an agreeable slightly-aromatic odour, is rather bitter to the taste, and very refreshing and restorative to the human frame after enduring great fatigue. It contains the same active principle as tea and coffee, called Theine ; but does not possess the volatile and empyreumatic oils of those substances. It is calculated that about 8,000,000 lbs. of this substance are consumed annually in South America.

The leaves of many plants have been used as substitutes for Tea, but they do not seem to contain the same alkaloid. Some of these will be found in Case 63.

Coffee.—In Cases 64, 65, and 66, the analysis of Coffee, with varieties of the seeds, and substances used as substitutes for Coffee, are exhibited. The labels accompanying them are as follow :—

Coffee.

(*Coffea Arabica.*)

The Coffee plant belongs to the natural order *Cinchonaceæ,* which contain the plants yielding Quinine. It is an evergreen shrub with oval, shining, wavy, sharp-pointed leaves, white fragrant flowers with projecting anthers, and oblong pulpy berries which are at first green, then of a bright red, and afterwards purple. Each berry contains two seeds, which are covered over with a tough membrane called "parchment." The seeds alone are used in the preparation of Coffee. The Coffee plant is indigenous in southern Abyssinia, where it grows wild over the rocky surface of the country. In the fifteenth century it was introduced into Arabia; in the sixteenth century, into Constantinople; and in 1652, the first coffee shop was established in London. It is now cultivated in Ceylon, the East and West Indies, and in South America.

The Coffee plant attains a height of from ten to fifteen, or twenty feet. It is planted in nurseries, and at the end of three years bears fruits and seeds, and continues to do so for twenty years. The seeds vary in size according to the countries in which they are produced. The best seeds are obtained from the Yemen, the southernmost province of Arabia; these yield the richest Mocha Coffee.

The separation of the seeds from the pulp and parchment of the fruit is a complicated process. The berries are first fermented, the pulp cleared away and the seed dried in the parchment; the latter is afterwards bruised and separated from the seed, which is immediately placed in bags to render permanent the greenish colour that the unroasted Coffee bean possesses. In its unroasted condition the bean consists of a horny mass, which, after it is submitted to roasting, yields very different products from those which existed before that process. Exposure to heat develops the peculiar volatile oils, and the astringent acid, on which the flavour of coffee depends. The oil acts as a stimulant upon the nervous and vascular system, producing an agreeable excitement of the mind, and a gentle perspiration on the skin. It also tends to impede the waste of the tissues of the body, and when taken in too large quantities produces sleeplessness and palpitation of the heart. The acid called Caffeo-tannic, found in rosted Coffee, acts as a light astringent; but in this respect Coffee does not act so powerfully as Tea. It contains a similar active principle

to that of Tea, called *Caffeine.* The yearly consumption of Coffee in the world is calculated to be about 600,000,000 of pounds.

Coffee.

(*Coffea Arabica.*)

The chemical properties of the Coffee-berry are altered by roasting, and it loses about 20 per cent. of weight, but increases in bulk one third or one half. Its peculiar aroma, and some of its other properties, are due to a small quantity of an essential oil, only one five-thousandth part of its weight, which would be worth about 100*l.* an ounce in a separate state. Coffee is less rich in Theine than Tea, but contains more sugar, and a good deal of cheese (Casein). One hundred parts consist of:—

Water - -	12·000.
Caffeine, or Theine	1·750.
Casein, or Cheese	13·000.
Aromatic Oil -	0·002.
Sugar - -	6·500.
Gum - -	9·000.
Fat - - - -	12·000.
Potash with a peculiar acid -	4·000.
Woody Fibre -	35·048.
Mineral matter -	6·700.

or,

Water - -	12·00.
Flesh-formers	14·75.
Heat-givers -	66·25.
Mineral matter	7·00.

In the usual way of making Coffee, the flesh-formers are thrown away: the addition of a little Soda to the water partly prevents this waste. The Case shows the various ingredients in 1 lb. of Coffee.

1. Water in 1 lb. of Coffee—1 oz. 407 grs.
2. Caffeine or Theine in 1 lb. of Coffee—122 grs.
3. Casein, or Cheese in 1 lb. of Coffee—2 ozs. 35 grs.
4. Aromatic Oil in 1 lb. of Coffee—1½ gr.
5. Gum in 1 lb. of Coffee—1 oz. 192 grs.
6. Sugar in 1 lb. of Coffee—1 oz. 17 grs.
7. Fat in 1 lb. of Coffee—1 oz. 402 grs.
8. Potash, with a peculiar acid, in 1 lb. of Coffee—280 grs.
9. Woody fibre in 1 lb. of Coffee—5 ozs. 262 grs.
10. Mineral matter in 1 lb. of Coffee—1 oz. 31 grs.

Cocoa, Chocolate.—In Case 63 is exhibited the analysis of Cocoa, with the fruits and seeds of the plant. The following are the explanatory labels:—

COCOA.

(*Theobroma Cacao.*) Nat. Ord. BYTTNERIACEÆ.

Cocoa is the seed of the Chocolate Plant, a small tree with dark-green leaves, growing in Mexico, Carraccas, Demerara, and other places. It produces an elongated fruit in shape between a Cucumber and a Melon, which grows directly from the stem or main branches. The seeds or beans that afford the Cocoa are imbedded in the fruit in rows in a spongy substance, and are about twenty or thirty in number. When the fruit is ripe the seeds are taken out, cleaned, and dried, and sometimes a little fermented. The best cocoa is made from these seeds, which are shelled from the outer husks and then roasted. In the inferior kinds the shell is ground up with the seeds. COCOA-NIBS are seeds merely roasted and crushed after being shelled. COCOA-PASTE is the seed ground down, and when this paste is mixed with sugar, and flavoured with aromatics, as Vanilla, it is called Chocolate. The peculiar flavour of Chocolate is due more especially to Vanilla. This latter substance is the fruit of the *Epidendrum Vanilla*, an orchidaceous plant, a native of Mexico, and contains a volatile oil which gives the flavour to Chocolate. Soluble, Rock, Flake, and other Cocoas are the whole seeds ground and mixed with Sugar, Gum, Starch, etc. Cocoa is a rich and nutritious food, containing in 100 parts, 51 of Butter, 22 of Starch and Gum, 20 of Gluten or flesh-forming matter, and about 2 parts of a principle called THEOBROMINE, to which no doubt its peculiar character is due: Theobromine contains more Nitrogen than Theine, the active principle of Tea and Coffee. The quantity of Cocoa consumed in the United Kingdom in 1852 was 3,382,944 lbs.

COCOA.

(*Theobroma Cacao.*)

Cocoa, though drunk like Tea and Coffee as a beverage, differs from them remarkably in composition. The distinguishing feature of its composition consists in the large quantities of fat and albumen which it contains; so that Cocoa not only acts as an alternative through its Theobro-

mine, but as a heat-giving and flesh-forming food. 100 parts of Cocoa contain:—

Water	5·0.	or,	WATER	5·0.
Albumen	20·0.		FLESH-FORMERS	22·0.
Theobromine	2·0.		HEAT-GIVERS	69·0.
Tutter	50·0.		MINERAL MATTER	4·0.
Woody Fibre	4·0.			
Gum	6·0.			
Starch	7·0.			
Red colouring matter	2·0.			
Mineral matter	4·0.			

The Case shows the ingredients in 1 lb. of Cocoa paste.

1. 1 lb. of Cocoa nibs.
2. 1 lb. of Cocoa paste.
3. Water - - - - 350 gr.
4. Albumen and Gluten 3 oz. 85 gr.
5. Theobromine - - - 140 gr.
6. Butter - - 8 oz.
7. Gum - - - - - 426 gr.
8. Starch - - 1 oz. 53 gr.
9. Woody fibre - - - 280 gr.
10. Colouring matter - - 140 gr.
11. Mineral matter - - - 280 gr.

GROUP III. NARCOTICS.

The substances taken as food, and arranged under the head of Stimulants, when taken in excess affect the nervous system, more especially the brain, and then become narcotics. This is especially the case with alcohol. There is a fascination connected with the action of such substances that has in all ages and countries led mankind to indulge in them frequently to a dangerous extent. In northern climates alcohol has been especially consumed for this purpose. Besides alcohol, many substances whose stimulant effect is less, and narcotic action more decided, have been consumed. Of these, tobacco, opium, and Indian hemp may be taken as special examples.

Tobacco.—Although tobacco has been only comparatively recently introduced amongst the inhabitants of the Old World, it is more extensively employed than any other

narcotic. It is the produce of various species of the genus *Nicotiana.* The practice of smoking the leaves of these plants was introduced from the New World. The species which is a native of America, and which supplies the greater proportion of the tobacco smoked in Europe, is the *Nicotiana Tabacum.* The leaves of these plants contain an active principle called *Nicotine* or *Nicotia,* which is the agent that produces the narcotic effect experienced in smoking. This narcotic effect resembles in some measure that of alcohol. Tobacco has, however, a less stimulant effect than alcohol, and produces, especially at first, a greater derangement of the general nervous system.

Species of *Nicotiana* are indigenous in the Old World, and *N. rustica* and *N. Persica,* inhabitants of the Levant and Persia, supply a limited quantity of the tobacco smoked in Europe. They contain less nicotine than American tobacco, and are used in the manufacture of the milder cigars and tobaccos.

Cases 112, 113, 114, and 115 contain a series of specimens of the leaves of species and varieties of tobacco cultivated in various parts of the world, with specimens also of the cigars and tobaccos manufactured from them. These have been presented to the Museum by Messrs. Lambert and Butler, of Drury Lane, London.

The following Table exhibited in the Museum shows the relative annual consumption of Tobacco in different countries, in ounces per head of the male population :—

	ozs.
United Kingdom	65
France	88
Belgium	143
Holland	131
Denmark	127
Norway	101
Sweden	70
Russia	40
Austria	108
Zollverein	155

	OZS.
Sardinia - - - -	45
Tuscany - - - -	40
Papal States - - -	32
Spain - - - -	76
Portugal - - -	56
United States - - - -	119

Tobacco is also consumed in large quantities in the manufacture of Snuff. For this purpose the stalks and ribs of the tobacco leaves are employed. Examples of varieties of Snuff used in this and other countries will be found in Cases 70 and 112.

Opium.—Opium is the juice of the Poppy (*Papaver somniferum*). It is obtained from the cultivated plant, by piercing the capsules and collecting the juice as it exudes. It is then dried and formed into small masses, and covered with leaves of various kinds, or other thin substances, as mica, &c.

The Poppy is cultivated extensively for this purpose in Turkey, Egypt, and the East Indies. It has also been introduced into Europe, but the opium is not so powerful.

Opium is indebted for its active properties to a principle called *Morphia* or *Morphine*. Besides morphia, it contains other active principles, which are also narcotic. These are exhibited in Case 68, which has been presented to the Museum by the General Apothecaries' Company, Berners Street, London.

These active principles are combined with caoutchouc, gum, and other vegetable matters in the opium of commerce.

Opium is used extensively as a medicine, on account of its power of alleviating pain and inducing sleep. In small doses it acts as a stimulant. On account of this latter property and its subsequent soothing influence, it has been indulged in by man, and is consumed largely in China and other parts of the world as a dietetical luxury. When taken for this purpose it is smoked, and is generally consumed with tobacco or some other leaf in a pipe. Pipes used for this purpose in China are exhibited in Case 90,

with a collection of Chinese tobaccos, most of which appear to contain opium.

The practice of "Opium eating," as it is called, exerts a most prejudicial effect upon the system; and although not rapidly destroying life, the victim of this habit is after a time rendered perfectly miserable if not able to procure this indulgence. As is the case with alcohol and tobacco, the system becomes accustomed to the use of this narcotic, and prodigious quantities have been consumed by those who have addicted themselves to the practice of taking it for the sake of its effect on the system. The history of its effects upon the mind has been described by two distinguished literary men in this country, Samuel Taylor Coleridge and the "English Opium Eater."

Case 69 contains, besides opium, specimens of other narcotic agents. Of these only two are indulged in extensively by man as narcotics.

The *Cannabis sativa*, common Hemp, when grown in tropical or sub-tropical climates, yields a narcotic principle which produces effects more analogous to those of alcohol than to those either of tobacco or opium.

In South America, under the name of Coca, the leaves of the *Erythroxylon Coca* are consumed as an intoxicating agent. The plant grows wild in the woods, and the victim of this indulgence seeks it in the wild solitudes of the forest. Its stimulant effects are said to be very remarkable and permanent, enabling persons under its influence to perform great feats of strength and agility.

In Kamchatka, a species of fungus, the *Amanita Muscaria*, is employed by the natives for the purposes of narcotic indulgence. It acts first as a stimulant, and then deranges the brain, producing in large doses entire loss of consciousness. Its effects are oftenludicrous. "If," says Langsdorf, "a person under its influence wishes to step over a straw or small stick, he takes a stride or jumps sufficient to clear the trunk of a tree; a talkative person cannot keep silence or secrets; and one fond of music is perpetually singing."

Of the other narcotics in Case 69, some are used medicinally, as the Stramonium or Thorn Apple (*Datura Stramo-*

nium); others, as the Nux Vomica (*Strychnos Nux Vomica*), containing Strychnine and Cocculus Indicus, are used for adulterating intoxicating beverages. The Betel Nut (*Areca Catechu*) is chewed in India with long pepper (*Piper longum*), and it is probable that its alleged narcotic effects are due to this agent. The Betel Nut contains a large proportion of tannic acid, and the astringent effect of this substance may render it agreeable to the natives of hot countries. Enormous quantities of Betel Nuts are consumed as a masticatory in the countries of the East.

The fruits of narcotic plants are often consumed by mistake in this country, and produce fatal effects. Specimens of the Deadly Nightshade (*Atropa Belladonna*), Woody Nightshade (*Solanum Dulcamara*), and Garden Nightshade (*Solanum nigrum*), preserved in Goadby's solution, will be found in the Museum. The berries of all these plants are poisonous.

There is another British plant containing a poisonous narcotic principle, the root of which has been occasionally mistaken for Horseradish, with fatal effects. This is the Aconite or Wolf's Bane (*Aconitum Napellus*). The roots of these two plants are exhibited in the Museum for the purpose of indicating their difference.

Many plants belonging to the order Umbelliferæ, to which Hemlock (*Conium maculatum*) belongs, contain a poisonous narcotic principle analogous to that found in Hemlock. The leaves of these plants, especially the Marshwort (*Helosciadium nodiflorum*), are often mistaken for Watercresses (*Nasturtium officinale*).

GROUP IV. ACCESSORIES.

Under this head are placed certain substances very common in all kinds of food, but which do not appear either to enter into the system and form a necessary part of the food, or to act in any way as the preceding group of auxiliary foods. The most prominent of the substances are Woody Fibre, Gum, and Gelatine. The two first occur in most kinds of vegetable foods, and have been frequently

regarded as heat-givers, whilst the latter is a constant constituent of animal food, and has been regarded as a flesh-former.

Woody Fibre, or *Cellulose,* forms the walls of all kinds of vegetable cells. Wherever vegetable food is eaten whole or solid it is taken into the stomach. In experiments upon animals it has been found that little or none of this substance is digested, but it passes through the body unchanged. In the vegetable world it is sometimes converted by the growth of the plant into starch, and this can be effected by the action of sulphuric acid away from the plant. Thus if a piece of wood or paper is touched with sulphuric acid, and iodine afterwards added, the characteristic blue of starch will be afforded. But it does not appear that the stomach of man can effect this change to any extent. Hence Cellulose in the food must be regarded as a mechanical agent serving to make up the bulk, and afford a larger surface for more easily digestible substances to be acted on.

Gum is soluble in water, and found generally present in the juices of plants. It may be regarded as a fixed condition of dextrin. It is incapable of the change into sugar which takes place in dextrin, and is thus unused as a heat-giving food.

The quantities of Cellulose and Gum in one pound of different kinds of food will be seen in the following table:—

	Cellulose.		Gum.	
Potatoes	0 oz.	327 grs.	0 oz.	27 grs.
Rice	0	218	0	87
Wheat	0	109	0	109
Barley	2	146	0	146
Oats	2	0	0	218
Maize	0	350	—	
Rye	1	284	0	371
Beans	1	206	1	57
Peas	1	263	1	193
Lentils	2	0	1	153
Buckwheat	3	14	0	140

The quantities of these substances in food are presented to the eye in Case 122.

Gelatine is in the animal world what cellulose is in the vegetable. All animal food contains gelatine. The cells of which animal tissues are formed are composed of gelatine. This substance is soluble in hot, but not in cold water. It is the basis of soups, jellies, and other articles of diet. It can be dissolved in hot water, purified, and reduced to any degree of consistence. In consequence of this, it is used extensively in the arts for modelling and ornament. (See the Animal Product Museum.) It abounds in the sinews, tendons, skin, and bones of animals, and from these sources it is obtained for making soups and jellies. It is most prized when obtained from the sound or swimming bladder of the sturgeon (*Accipenser Sturio.*) This part of the fish is prepared and brought into the market under the name of Isinglass. It is chiefly imported from Russia. The manufacture, quality, and varieties of this substance are illustrated in Cases 77 and 78.

Although popularly regarded as a highly nutritive substance, there is every reason to believe that gelatine, like cellulose and gum, never enters into the composition of the blood, or takes part in the nutrition of the body. It is absent from the egg that forms the young chick; it is absent from milk that nourishes the young animal; it is absent from the blood that feeds every tissue; hence it may be concluded that its presence in the tissues arises from the decay of fibrine and albumen, and that it is one of the forms which the nitrogenous substances take before they are entirely eliminated from the system.

The greater proportion of the flesh of our animal food consists of Gelatine, as will be seen from the following table.

One pound of the following meats contain of gelatine :—

	oz.	grs.
Veal - - -	1	82
Beef - - - -	1	62
Mutton - - -	1	52
Pork - - -	0	85

There are many other facts that show that Gelatine is not a nutritious article of diet. It should therefore be recollected that, in supplying jellies and soups, it is not the substance which thickens and gives richness to the soup that acts as food, but the other things which accompany it.

ANIMAL FOOD.

The substances used as food derived from the Animal Kingdom have at present been separated from those obtained from the Vegetable Kingdom. This department of the Museum is not so fully developed as that of the food derived from the Vegetable Kingdom. Animal food is composed of the same materials as vegetable food. It is formed of the same elements, and presents the same proximate principles. It contains water and mineral matters of the same kind as plants. Its heat-giving substances appear in the form of fat, and its flesh-forming substances in the form of fibrine and albumen.

Of all animal foods, Milk is the most important, as it may be regarded as the type of human food. Case 71 contains an analysis of several kinds of Milk, and is accompanied with the following labels :—

Milk.

Milk is a substance formed in the animal body as the food of the young of the Mammalian class of animals. As it nourishes the young animal for so long a time it must contain all the elements necessary to the nutrition of the body, and Milk is consequently regarded as the type of the food of animals. It consists of *Water* in which are suspended, or dissolved, *Butter*, *Sugar*, *Caseine* or *Cheese*, and various *Salts*. The Water and the Salts represent the *Mineral*, the Sugar and the Butter the *Carbonaceous* or *Heat-giving*, and the Caseine the *Nitrogenous* or *Flesh-forming* principles of food.

The milk of the Cow is extensively employed as an article of diet in Europe. In Sweden and Denmark, Sheep's

milk is used; in Switzerland, Goats' milk; in Lapland, Reindeers' milk; and in Tartary, Mares' milk. In England the milk of the Ass, on account of its resemblance to Human milk, is frequently employed for young Children as food. When milk is allowed to stand, the butter rises to the surface in the form of "cream." Butter is formed from cream by the process of "churning." The caseine is held in solution in the milk by the aid of certain salts; when these are removed by acids the caseine coagulates, and forms "curds." When the curd is removed with the butter and pressed, it forms cheese. The best and highest-priced cheeses are those in which there is most butter. The caseine without the butter is hard and indigestible.

The Sugar of Milk is called *Lactose*. It is sometimes separated for dietetical or medicinal purposes. It is readily converted into an acid called *Lactic acid*. This acid forms in milk which has been kept, and from this cause the milk becomes curdled. The sugar of milk may be fermented, and in some parts of the world they make alcoholic beverages from milk. Milk is preserved in various ways so that it may be taken on long voyages, or otherwise employed as a diet where living animals cannot be kept to produce it. It is preserved both in a liquid and solid state. The latter mode of preparation appears to have the advantage.

MILK.

Milk is one of the most important articles of diet. The young of all the Mammalia are fed entirely upon it during the first period of their life. Its composition may be therefore taken as the type of food. It varies in composition in different animals. In the Cow it consists in 100 parts:—

Water	86·0.	or,	WATER	86·0.
Casein	5·0.		FLESH-FORMERS	5·0.
Butter	3·5.		HEAT-GIVERS	8·0.
Sugar of Milk	4·5.		MINERAL MATTER	1·0.
Salts	1·0.			

The composition of Human milk and Asses' milk, as contrasted with Cows' milk, may be seen as under,—

	Cows' milk.	Human milk.	Asses' milk.
Water in 100 parts	86	$89\frac{1}{2}$	90
Flesh-formers, Casein	5	3	2
Heat-givers { Butter	$3\frac{1}{2}$	3	$1\frac{1}{2}$
Heat-givers { Sugar of Milk	$4\frac{1}{2}$	4	6
Salts	1	$\frac{1}{2}$	$\frac{1}{2}$
	100	100	100

In the Case are exhibited,—

1. 1 lb. of Cows' milk, which contains—
2. Water - - - 13 oz. 333 gr.
3. Casein - - - 350 gr.
4. Butter - - - 245 gr.
5. Sugar - - - - 315 gr.
6. Mineral matter - - - 70 gr.

1. 1 lb. of Human milk, which contains—
2. Water - - - 14 oz. 41 gr.
3. Casein - - - - 210 gr.
4. Butter - - - 210 gr.
5. Sugar - - - - 280 gr.
6. Mineral matter - - - 35 gr.

1. 1 lb. of Asses' milk, which contains—
2. Water - - - 14 oz. 76 gr.
3. Casein - - - 140 gr.
4. Butter - - - - 105 gr.
5. Sugar - - - - 420 gr.
6. Mineral matter - - - 35 gr.

The Flesh of Animals.

Cases 72 and 72A contain the analysis of a pound of various kinds of flesh. These analyses have been founded on the large table exhibited in the Museum, and which is as follows:—

Assumed Average Composition of Entire Carcasses of Butchers' Meat.

[Lawes and Gilbert.]

Animals as fattened for the Butcher.	Composition per cent. of Carcasses, excluding head and feet.					Actual weight and composition of Carcasses in lbs.					
	Mineral Matter.	Dry Nitrogenous Substance.	Fat.	Total dry Substance.	Water.	Total Weight.	Mineral Matter.	Dry Nitrogenous Substance.	Fat.	Total dry Substance.	Water.
						lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Calf - -	4·5	16·5	16·5	37·5	62·5	150	$6\frac{3}{4}$	$24\frac{3}{4}$	$24\frac{3}{4}$	$56\frac{1}{4}$	$93\frac{3}{4}$
Bullock -	5·0	15·0	30·0	50·0	50·0	900	45	135	270	450	450
Lamb -	3·5	11·0	35·0	49·5	50·5	45	$1\frac{1}{2}$	5	$15\frac{3}{4}$	$22\frac{1}{4}$	$22\frac{3}{4}$
Sheep -	3·5	12·5	40·0	56·0	44·0	90	$3\frac{1}{7}$	$11\frac{1}{4}$	36	$50\frac{2}{5}$	$39\frac{3}{5}$
Pig* - -	1·5	10·0	50·0	61·5	38·5	160	$2\frac{2}{5}$	16	80	$98\frac{2}{5}$	$61\frac{3}{5}$

* In the "Carcasses" of Pigs, the head and feet are generally included; but here, for comparison with the other animals, they are excluded.

The label containing the analysis of the meats is as follows :—

Flesh used as Food.

These Cases are intended to illustrate the quantities of flesh-forming, heat-giving, and mineral matters in the most common forms of animal food. Although the flesh of animals does not in many instances contain bulk for bulk more nutritive matter than vegetable food, its flesh-forming constituents are found to be more easily digestible. The following table gives the composition in 100 parts of Veal, Beef, Mutton, and Pork.

	Mineral matter.	Gelatine.	Fibrin & Albumen	Fat.	Water.	Total.
Veal - - -	4·5	7·5	9·0	16·5	62·5	100·0
Beef - - -	5·0	7·0	8·0	30·0	50·0	100·0
Mutton - -	3·5	7·0	5·5	40·0	44·0	100·0
Pork - - -	1·5	5·5	4·5	50·0	38·5	100·0

	Veal. 1 lb. contains.		Beef. 1 lb. contains.		Mutton. 1 lb. contains.		Pork. 1 lb. contains.	
	oz.	grs.	oz.	grs.	oz.	grs.	oz.	grs.
Water - - -	10	—	8	—	7	16	6	69
Gelatine - -	1	82	1	62	1	52		385
Fibrin and Albumen -	1	199	1	122		385		315
Fat - - -	2	281	4	340	6	176	8	—
Mineral matter		312		350		245		105

The quantities of gelatine put down here must be regarded as only approximative, as further experiments are needed to determine the exact quantity of gelatinous matter in different kinds of flesh.

The animal food has at present been arranged according to a natural classification.

VERTEBRATE ANIMALS.

1. *Mammals.*—This includes the Ox, Sheep, Pig, Deer, and other animals which are eaten as food. It is intended

to exhibit in this department all the products of this class of animals which can be exhibited, and which will in any way illustrate the history or economy of food.

2. *Birds.*—Under this head the various creatures of this class which are eaten, as well as their eggs, will be exhibited.

3. *Reptiles.*—The Turtle, the Frog, the Terapan, the Iguana, and the eggs of the Crocodile, fall under this head for exhibition and illustration.

4. *Fishes.*—The Isinglass series before mentioned as the product of the Sturgeon is exhibited under this division. Several fish dried, stuffed, or put up in glycerine, are also exhibited. The following labels accompany some of the more common fish:—

THE COD.

(*Morrhua vulgaris.*)

As an article of food, the Cod is perhaps the most important of all fish brought to our markets. It has a wide geographical range extending from Iceland to very nearly as far south as Gibraltar; and, on the shores of the American Continent, from the 40th to the 60th degree of latitude: it does not occur in the Mediterranean. Cod is found in considerable quantities round the coasts of England, Scotland, and Ireland. The London market was formerly supplied from the Dogger bank, but of late years the fish have increased on our own coast to such an extent that the London market is now almost entirely supplied from the coasts of Lincolnshire and Norfolk.

The Cod inhabits deep water, and is fished for with lines and hooks at a depth of 150 to 300 feet from the surface; it is a very voracious fish, and easily taken, biting greedily at almost everything offered to it. The baits used are generally pieces of fish, limpets, whelks, etc. Its natural food is small fish, worms, and various species of Crustacea and Mollusca. On the coast of Newfoundland, where the fish are very plentiful, as many as 400 and 500 are occasionally taken in a single day's fishing by one man. The Cod is in its highest perfection during the months of October, November, and December; it spawns in February, and is wonderfully prolific: as many as 9,000,000 of ova have been found in the roe of one female.

The Herring.

(*Clupea Harengus.*)

The Herring, leaving the deep sea towards the end of the summer months, is attracted to our shores by the increased temperature of the shallow waters, for the purposes of spawning. It is a curious and bountiful provision of nature that forces the Herring, and other fish usually distributed through the deeps, to congregate together and visit our shores in such immense abundance, at a time when they are in their highest perfection, and when most fitted for human food. The Herring sheds its roe about the beginning of November, and is then, as an article of diet, worthless; the shoals then disappear from our coasts, though individual specimens are occasionally taken all the year round.

The young fry are very numerous on the Yorkshire coast during the summer months. They are the favourite food of the dog-fish, and are frequently driven on shore in large quantities, pursued by troops of those voracious fishes. During the autumn and winter months the mouth of the Thames is a great resort for the young Herrings, where numbers of them are taken by fishermen in the nets used for sprats. The usual mode of fishing for Herrings is with the drift-net; a dark night with a smart breeze is considered the most favourable time for catching them. Great care is requisite in casting the net; and the direction of the wind and currents have to be taken into consideration. The fish strike the net, and in endeavouring to force their way through the meshes, get fixed by the head and gills, and in this state are drawn into the boats by thousands.

Red Herrings are prepared by salting and soaking in brine for several days, and then drying in rooms heated by wood fires; Bloaters are Herrings only slightly cured. The annual supply of Herrings at Billingsgate Market is estimated at upwards of 120,000 tons, valued at about 1,200,000*l.* sterling.

The Sprat.

(*Clupea Sprattus.*)

The Sprat was formerly considered by naturalists to be the young of the herring as well as that of the pilchard; it is now generally admitted to be a distinct species. The Sprat comes into season in November and continues so all

the winter months, affording to the poorer classes a cheap, relishing, and wholesome food. The quantity sold in the London markets during the season is immense. About 500 boats are annually employed in the Sprat fishery; occasionally so great is the take of these fish, that thousands of tons are sold to farmers, at from 6*d.* to 8*d.* per bushel, as manure for the land. Most fish are caught on dark and foggy nights. In the spring the Sprat retires to the deep waters round our southern coast, and continues there during the summer months.

In addition to these are exhibited the following fish :—

Sole - - -	(*Solea vulgaris*).
Red Mullett - -	(*Mullus surmuletus*).
Mackerel - -	(*Scomber vulgaris*).
Trout - - -	(*Salmo Fario*).
Perch - - -	(*Perca fluviatilis*).
Smelt - - -	(*Osmerus eperlanos*).
Sapphirine Gurnard-	(*Trigla Hirundo*).
Lemp-sucker - -	(*Cyclopterus Lumpus*).
Haddock - -	(*Morrhua æglefinus*).
Lamprey - -	(*Petromyzon marinus*).

INVERTEBRATE ANIMALS.

1. *Articulate.*—To this group belong the Insects and Crustacea.

Insects are not extensively eaten. Nevertheless they form occasionally articles of diet, as the White Ants in Case 126. The Bee, it is well known, collects sugar from fruits, and deposits it in the form of honey. A hive of living Bees is to be seen working in the Food Museum. The uses of the wax of their cells are exhibited amongst the animal products applied to the arts. The following label accompanies them.

Bees.

Domestic Bees come originally from Greece. They live in colonies of ten to thirty thousand *Neutral Working Bees*, or Nymphs as they are called, from six to eight hundred Males, called drones, and of a Single Female, the Queen

or Sovereign of the hive. The female does no work, being treated with the utmost respect and care, and allowing no rival in the hive. When she moves out, the bees form in line for her accommodation and never turn their backs upon her. A few days after her birth, if the weather be fine and warm, she leaves the hive in company with the drones, ascending in the air with them out of sight. Forty-six hours after her return she begins to lay eggs. In her first summer the eggs are few, and produce working bees. During winter she rests, but in spring becomes very active, laying 12,000 eggs in three weeks. In the eleventh month of her age she lays eggs producing males or drones along with those of nymphs or working bees. A few days after the laying, a little helpless white larva is hatched from the eggs. The larvæ are fed with a sort of *bouillie* varying in quality according to the age and sex of the insect, by nurses set apart for them. By varying this food the nurses can change a working bee or neutral nymph, into a Queen. When a new female has gnawed through her cell, the hive becomes much agitated, many bees trying to keep her in the cell, while the Sovereign bee rushes with fury to destroy the new claimant for royal honours, obstructed respectfully by the bees of the hive. In apparent rage the old Queen leaves the hive, or *swarms*, attended by most of her subjects, both neutrals and males, whilst the young bees remain and create the new female their Sovereign. No strangers are allowed in the hive; if one comes, it is uniformly destroyed and its body dragged out.

Working bees collect bee-bread and wax from flowers, the wax chiefly from the poplar tree, although they also can secrete it. Brushing the pollen from the stamens they place it in little baskets on their limbs. They also take a resin called *propolis* from the flowers with which to plaster up chinks, &c. in their hives.

The combs or cells for the young and for storing the honey as food are made of wax. Openings are left between them for passages. The cells are hexagonal and nearly alike in size, except the cells for the Queen, which are much larger and cylindrical.

The *Crustacea* afford several species of edible animals, belonging to the groups of Lobsters, Crabs, Prawns, and Shrimps. Some of them are exhibited in Case 126.

Molluscous Animals.

These creatures, embracing the shell-fish of our rivers and oceans, and the snails of our shores, afford a large number of edible forms. They may be divided for dietetical purposes into two groups,—those with one shell, and those with two shells—univalves and bivalves. Amongst the latter the most important is the Oyster (*Ostrea edulis*). In Case 79 is an interesting series illustrating the growth of the Oyster; from which it will be seen that the young Oyster is at first a locomotive being, and only subsequently comes to rest, and gradually grows, and is not fit to eat until it is five or six years old. Shells of the different varieties of Oysters brought to the London markets are exhibited in the same Case. In Case 80 is exhibited the Mussel (*Mytilus edulis*), the Pecten or Scallop (*Pecten maximus*), and the Cockle (*Cardium edule*).

In Case 81 is a series of univalve mollusks, which include the Whelk (*Buccium undatum*), and the Periwinkle (*Littorina littorea*) from the sea, and the common Snail (*Helix aspersa*) and the Roman Snail (*Helix Pomatia*) from the land. The latter is very abundant on the Chalk Downs of this country, and is at the present moment a favourite article of diet in France.

MISCELLANEOUS.

In the preceding description some Cases in the Museum, which either on account of their miscellaneous character, or their exhibiting a new preparation rather than a new substance, have been omitted. The first of these Cases demanding attention is the collection of food from China. As this collection has a unity and completeness of its own, it was thought desirable not to separate it. It is hoped that other collections of the same kind, and illustrating national peculiarities of diet, may be formed, and presented to the Museum.

The Chinese collection is contained in Cases 90, 91, and

92. They were forwarded to this country through His Excellency, Sir John Bowring, and collected under the direction of Mr. Cane, the British Consul at Shanghae. The following is an extract from the letter of advice received from Mr. Cane, relating to this interesting collection:—

MEMORANDUM.

Case No. 1 contains a box with nine varieties of Chinese wine. These are the ordinary kinds in use in this part of the empire, as will be seen from the statement they are chiefly distilled from different kinds of rice. The strongest and most common, Kow-liang, is procured in large quantities from Min-chwang, the port in Manchuria to be opened by the treaty of Tiensin. Nos. 3 and 5 are perfumed with the Kwei-hiva and Moh-li-hwa, which flowers are also greatly used in the scenting teas and various kinds of preserves. Nos. 7, 8, and 9 are mixed with some medicinal preparations, and may be regarded more as liqueurs. No. 8, mixed with Gen-sing, is considered as very strengthening. The same box also contains a specimen of native soy, and four bottles of various kinds of oil. The first is vegetable oil in ordinary use here, both for culinary purposes and lamps; the second, made from the same bean that is used in the manufacture of soy; the third is rather expensive oil, made from a pea, and only used in culinary purposes; and fourth, the tea-seed oil, greatly used, amongst other things, by women for dressing their hair. Further particulars of these, with districts from which they come, and wholesale prices, will be found in the statement. Also a tin box containing fourteen varieties of Chinese cakes: these are perishable; but as they are very inexpensive it was thought advisable to send a selection of them, as calculated to give a very good idea of the style of light confectionery amongst the Chinese. All particulars procurable relating to them will be found in the statement. Various preserved fruits and vegetables in thirty-one sealed canisters; of these the Chinese have almost every possible variety, preserves of all kinds forming a great item in all their feasts. Here are fruits, flowers, roots, and vegetables preserved with sugar, salt, and treacle, many of them having no analogy to English preserves; in such cases only the Chinese name has been given. The San-cha and Yang-mei are very

piquant and pleasant fruits, greatly used in confectionery and preserves, both by Europeans and natives here. With these are also six sealed canisters of sweatmeats, different preparations of sugar, treacle, and butter, not at all unlike those of England, either in manufacture or taste. Case No. 2 contains sixteen different Chinese tobaccos, numbered consecutively. These are from all districts, but most of them are procured from Han-kow, the new treaty port on the Yangtsze Keang, about 200 miles above Ninking. Many of them are native to that district; but Nankow also seems the emporium at which those of others are collected, and then distributed to the ports on the Yangtsze, almost every kind in Shanghae being procurable from there. The native names of all these varieties have been given, also the wholesale price per pecul at the largest tobacconists in this city. The pipes sent are all specimens of those in common use, indiscriminately by men and women. Sundry dried fruits and grains in boxes numbered from 1 to 15; amongst these will be found the Lichee and Longan, also several others from Tokien and Shantung provinces. No. 8 is the bean used in the manufacture of soy, and No. 13 the arrowroot from the root of the water-lily, large quantities of which are brought here from the Tae-hoo lake districts.

Teas, and the Flowers for scenting them.

This is not the season for procuring these. Mr. Fortune, who was last month in Shanghae, has promised his assistance in getting what is required at the right time. Amongst the few sent, numbered from 1 to 6, will be found three slabs of the brick tea. This principally comes from the province of Sze-chuen. It is not used, and scarcely known, in the southern parts of China. The lie or false teas are from the Canton province, and cannot be procured here at all. Nos. 5 and 6 are dried specimens of the Kuei-hwa and Môh-li-hwa, already mentioned, and greatly used for scenting teas. The flowers that are chiefly used for this purpose are the

Kwei-hwa,
Che-lan-hwa,
Môh-li-hwa (*Jasminii sp.*),
Mei-kwei-hwa,
Chang-kwei-hwa, and
Mei-hwa.

Gelatinous Substances.

Amongst these will be found three kinds of prepared seaweed, extensively used in Chinese cookery. Specimens of three kinds of glue (two being edible), fish-maws, Trepang, Beche-de-mer, and shark's fins are also here, and their wholesale prices at the large native dealers.

Sundries used as Food.

A few samples have been placed under this head. Nos. 1 and 2 are specimens of cinnamon and cassia buds from the Chekiang province. Nos. 3 to 7, various condiments, chiefly seeds used by Chinamen with their tea. Nos. 8, 9, and 10 are samples of the bamboo shoot, raw and preserved as a vegetable, in which form it is much used by the Chinese as a relish with their basins of rice.

Sundries not used as Food.

Chop-sticks: those of red wood and ebony are in the commonest use, the ivory being used by the higher classes; whilst in the north especially, a pair of chop-sticks in a case with a knife is often suspended from the girdle. Of sandal wood two specimens are enclosed. These are all imported from Singapore and the Straits, and much used by Chinamen for making the incense stick required for service in the temples. The sawdust, mixed with some chemical preparation, is also often used in scent bags, which hang as charms to the women's dresses.

British Consulate, Shanghae,
5th November 1858.

Chemical Principles contained in Vegetable and Animal Food.

Case 94, presented by Messrs. Hopkins and Williams, chemists, London, contain a series of chemical products obtained from plants used as food, as well as from animals. These substances are well worth examining as exhibiting in a separate condition many of the active principles possessed more especially by the auxiliary foods.

Compressed Vegetables.

The art of compressing vegetables so as to enable them to keep for a length of time, is now recognized generally as a valuable means of transporting vegetable food, both for soldiers and sailors. In Cases 93 and 93*a* are exhibited a variety of vegetable substances thus prepared. All that is necessary in order to render them ready for use is to put a certain quantity in boiling water, and when they become heated they are fit for use without further preparation. The vegetables in these Cases are principally exhibited by M. Cholet.

Preparations of Flours and Starches.

In Cases 124, 125, and 126 are exhibited a series of preparations of flours and starches. These preparations are remarkable for their purity and adaptation for the dietetical purposes for which they are intended. Each article is accompanied with a label descriptive of its composition and uses.

Vegeto-Animal Foods.

In Case 76 *a* will be found meat, biscuits, and vegeto-animal foods. These are compounds in which both animal and vegetable substances are combined, and are found useful in travelling where cooking cannot be employed.

Adulterations.

The extensive employment of various substances for the adulteration of food has led to the formation of a collection of those more commonly employed. In cases 108, 109, and 110, these substances are arranged according as they have been obtained from the animal, vegetable, or mineral kingdoms. They have been selected principally from the results obtained by Dr. Hassall, and made known in his work "On the Adulteration of Food." The following is a list of these substances, and the fraudulent purposes to which they are applied :—

Substances used in the Adulteration of Food.

Animal Substances.

	Used in Adulterating
Bone-dust - - -	Pepper, Sugar, &c.

Vegetable Substances.

	Used in Adulterating
Annatto - - -	Cheese and Milk.
Bay-leaves - -	Tea.
Beans (roasted) - -	Coffee.
Burnt Sugar - -	Porter, Stout, Vinegar, &c.
Capsicums - - -	Porter and Gin.
Cardamoms - -	Porter and Gin.
Catechu - - -	Tea.
Cayenne Pepper -	Mustard and Pepper.
Chamomile Flowers -	Beer.
Chicory - - -	Coffee.
Cocculus Indicus - -	Beer.
Coltsfoot - - -	Tobacco.
Coriander Seeds - -	Porter.
Dandelion Roots - -	Chicory.
Gamboge - - -	Confectionery.
Gluten - - -	Tea.
Grains of Paradise -	Beer.
Lentils - - -	Farinaceous food.
Linseed Meal - -	Pepper.
Liquorice - - -	Porter and Stout.

Logwood - -	Port Wine, Tea, &c.
Lupins (roasted) - -	Coffee.
Nux Vomica Seeds -	Beer.
Opium - - -	Porter.
Pea-flour - -	Pepper.
Potato Starch - -	Arrowroot, Cocoa, Honey, &c.
Quassia Chips - -	Porter and other Beers, Snuffs, &c.
Radish Seed - -	Mustard.
Rice ("Paddy") - -	Tea.
Rice-flour - -	Pepper, Mustard, &c.
Roasted Corn - -	Coffee.
Sago Meal - -	Cocoa, &c.
Sawdust - - -	Coffee.
Starch - - -	Coffee.
Sugar - - -	Coffee.
Sumach - - -	Snuff, &c.
Tobacco - - -	Beer.
Treacle - - -	Porter and Stout.
Turmeric - - -	Tea.
Wheat-flour - -	Confectionery.

Mineral Substances.

	Used in Adulterating
Acetate of Copper -	Pickles.
Alum - - -	Bread.
Antwerp Blue - -	Confectionery.
Armenian Bole - -	Cocoa, Anchovies, &c.
Blacklead - -	Tea.
Blue John (Fluoride of Calcium) - -	Confectionery.
Brickdust - - -	Chicory, Cayenne Pepper, Cocoa, &c.
Brunswick Green (light) -	Confectionery.
Brunswick Green (middle)	Confectionery.
Brunswick Green (deep) -	Confectionery.
Burnt Umber - -	Confectionery.
Carbonate of Ammonia ("Pop") - -	Bread.

Carbonate of Copper	Tea.
Carbonate of Lead	Tea.
Carbonate of Lime	Confectionery and Snuff.
Chalk	Sugar.
Chromate of Potash	Tea.
Chrome Green	Confectionery.
Chrome Yellow	Confectionery.
Daff, or "Daft"	Confectionery.
Dutch Pink	Tea.
Emerald Green	Confectionery.
Felspar	Tea.
Fuller's Earth	Tobacco.
Marble	Sugar.
Pipe-clay	Honey.
Prussian Blue	Tea.
Raddle or Reddle	Tea.
Red Lead	Cocoa, Anchovies, &c.
Red Ochre	Cocoa.
Common Salt	Beer, Tea, &c.
Silica (ground glass)	Snuff.
Smalts	Confectionery.
Steatite	Tea.
Sulphate of Copper	Pickles.
Sulphate of Iron	Tea.
Sulphuric Acid	Gin, &c.
Ultra-Marine	Confectionery.
Venetian Red	Tea.
Verdigris	Confectionery.
White Clay	Mustard and Confectionery.
Water	In almost everything.

MICROSCOPES.

The microscope has been found a useful instrument in the detection of the adulteration of food. In the Food Museum will be found two microscropes, one for opaque and the other for transparent objects, constructed by Mr. Ladd, Optician, Chancery Lane. These microscopes are fixed and adapted for the exhibition of objects in museums generally. The objects are also placed in moveable slides attached to the microscope, so that no derangement of the action of the instrument can occur from persons ignorant of its use. The objects exhibited are especially the microscopic structure of starch, with various substances used in the adulteration of food.

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